Forest Industries for Assam

COMPILED

BY

P. D. STRACEY, M. A., I. F. S.
Senior Conservator of Forests, Assam

INTRODUCTION

The original notes on Forest Industries, which were compiled by me in 1950 as the result of visits to various places of forest interest outside Assam and which were mainly intended for our officers have been considerably enlarged and added to since then, with a view to providing some guidance to the public on potential Forest Industries for the State.

Considerable assistance has been given to me by Sri B. Saikia, Special Officer for Forest Industries who has compiled several of the notes. Sri M. L. Saikia, Silviculturist and Botanical Forest Officer has also assisted me in contributing notes.

DATED SHILLONG :
THE 19TH APRIL 1952

P. D. STRACEY,
Senior Conservator of Forests, Assam.

NOTES ON FOREST INDUSTRIES FOR ASSAM

Contents

TEAK PLANTATION

If the private citizen is to go in for growing plantations of forest species on his spare land he can make no better choice than Teak, which is the most valuable tree in the world. It is true that one will have to wait for over 50 years before a Teak tree can be cut for timber, but as an investment to enhance the value of landed property plantations of Teak trees are an excellent proposition.

In South India there are extensive privately owned Teak forests, and in the Nilambur Division, Madras, mainly, some people have even planted out Teak copying the excellent Forest Department plantations. In Assam the first experimental Teak plantations were made at Kulsi in Kamrup by a German Forester named Mann in 1874, but after a couple of years the experiment was not continued. The growth of these first experimental plantations has been excellent and it is as a result of these first successful plantations that the Forest Department has, in the past 20-25 years, gone in for planting this valuable tree on a extensive scale. A small patch of Teak trees occurs near Margherita in the Lakhimpur District of Upper Assam, and they are said to have been planted by Italian Priests over 50 years ago. Their growth is also excellent, but generally speaking the species is not suitable to Upper Assam conditions.

Teak is a fist-growing tree in its early stages and thrives best on deep, well-drained soil ; it does not like the crests of ridges, where the soil is thin, or flat and swampy sites. It is however a very tolerant species and will survive almost any conditions—moreover the very high percentage of success achieved in planting this species and the short time required for maintenance before establishment makes it an excellent selection for the private forester. The hill-slopes of the Kamrup and Nowgong Districts and the bordering Khasi and Mikir Hills are quite suitable for the growth of teak, and as there are very large areas of such land, mostly privately owned, there seems no reason why these hills should not be planted up with Teak eventually. There is a saying that a bad Teak tree is better than a good tree of any other species; and certainly the reputation and money value of Teak as a timber supports this to some extent.

In India the first plantation of Teak was made in South India by a collector named Conally, in what is now the Nilambur Forest Division, in 1842.

Upto 1912 some 6,600 acres of Teak plantation were raised "on clearings in natural forest". Felling of the oldest plantation started in 1917 and replanting of teak was done. A sample of the plantation of 1846 was retained when the final felling was done in 1942 at the age of 96. This is known as Conally's plantation. On a visual estimate the trees appear to have an average height of some 120′, an average girth of some 9′—10′, and a spacing of about 40′.

The original rotation was fixed at 70 years but some of the original plantations were not felled until they were over 90 years. The present rotation is fixed at 63 years.

In additions to these plantations, a new series was started in 1917, by "converting suitable natural forest by clear felling and planting teak". Evergreen areas are avoided when making these plantations.

There is a total area of some 10,000 acres, or some 15 square miles, under Teak Plantation in the Nilambur Division to day.

Thinnings.—These are done at ages of 3, 6, 10, 18, 30 and 44 years, the first two being mechanical and the others silvicultural. As compared to Assam conditions and techinque the Nilambur thinnings appeared to be the minimum required. Certainly the plantations seem to close up very rapidly after a thinning. Research is being now carried out on a still heavier thinning technique to produce the required girth in a shorter period, and it is hoped to reduce the rotation to below 50 years, as gainst the present rotation age of 63 years.

It will be noticed that according to present technique the final thinning is one at about 2/3rd of the life of the tree.

The rotation age has been decided entirely according to the size of teak log which fetches the most value in West Coast timber markets on account of ease of export by boat and steamer, at present this is a medium sized rather than a large sized log. In other Divisions such as Wynaad, the emphasis is on large size logs for sawing, and the rotation is therefore longer.

Practically every size of thinnings is saleable, even poles of 4" to 6" diameter being extracted.

The extraction is by river in bamboo-rafts, the dragging to river-edge being done by buffaloes and elephants. The Plantations are situated mostly on easy ground.

A proportion of the plantations is done with the aid of cultivators, who pay for the privilege of growing a crop. The only operation done by them is to clear the area and plant rice and deliver the plantation to the Department after taking one crop in September. The teak plants appear to suffer suppression from the paddy, but are said to recover rapidly. Thereafter 2-3 weedings are given in the first year (the growing season is up to the end of November—December) and establishment is generally obtained in the 2nd year. Felling of the trees in the plantation coupe and removal of the felling debris is done by the coupe-holder. There is a complete absence of felling debris and abandoned logs in the plantations of the year because of the great demand for fuel in the locality and neighbouring town.

Plantation costs appeared to be about the same as in Assam.

Fire protection is by fire-lines and watchers.

Some of the Forest Officers I spoke to were of the impression that the 2nd Rotation plantations were generally not of the same quality as the 1st rotation plantations (the working plan denies that this is the case) and that teak should not be grown pure if the soil qualities are to be retained. Efforts have been made in the past to grow other species with Teak but the only species that appears to persist under the shade of teak are *Xylia xylocarpa* and *Hopea parviflora* on good soils.

It seems desirable to encourage any non-Teak tree that appears in a plantation in the hope that it will regenerate, naturally and so bring about a mixture in the course of time.

The main species growing in association with Teak in this Division are as follows :—

Swietenia macrophylla (Mahogany).
Xylia xylocarpa.
Lagerstroeimia lanceolata.
Terminalia paniculata.
Terminalia tomentosa.
Dalbergia latifolia (Rosewood).
Macaranga Roxburghii }
Bambusa arundinaceae } Tried for under plantation.
Vitex negundo }

The poorest results are seen on latertic soils and swampy sites, which are unsutiable for teak.

The following is a comparative statement of some Teak plantations :—

Plantation	Year	Average height	Average Girth	Average spacing	Remarks
1	2	3	4	5	6
Nilambur (Madras) ..	1846	120′	9′—10′	40′	Felled in 1942. 1st—2nd quality Nilambur.
Sagreibail (Mysore) ..	1863	100′	5′—6′	30′—35′	Has had 5 thinnings. 6th thinning in 1950.
Kulsi (Assam) ..	874	90′	5′—6′	..	Not thinned before 1935 All-India 3rd Quality.
Nilambur (Madras) ..	1906	90′—100′	5′—6′	35′	Has had 5 thinnings. 6th thinning in 1950. 1st Quality Nilambur or 2nd Quality All-India.
Nilambur (Madras) ..	1908	80′	5′	30′	Has had 5 Thinnings. 6th in 1952.
Dholai (Assam) ..	1918	90′	6′	13′	Thinned in 1938.
Nilambur (Madras) ..	1931	50′—60′	2′	20′	Has had 4 Thinnings. 2nd Quality Nilambur.
Kulsi (Assam) ..	1932	60′	2′	10′	Thinned once.
Jakhalabanda (Assam)..	1934	56′	2′—4″	10′	Thinned once.
Sagreibail (Mysore) ..	1937	40′—45′	2′—6′	12′	Thinned in 1948.
Loharband (Assam) ..	1937	45′	1′—9″	9′	Not thinned.
Matijuri (Assam) ..	1937	53	2′—3″	9′	Not thinned.
Kulsi (Assam) ..	1937	54′	1′—9″	10′	Thinned in 1949.
Hajo (Assam) ..	1937	39′	2′—0″	12′	
Sugunpara (Assam) ..	1937	47′	2′—7″	12′	
Diphu (Assam) ..	1937	68′	2′—10″	6′	Not thinned.
Jakhalabanda (Assam)..	1937	31	1′—3″	6′	Not thinned.
Lumding (Assam) ..	1938	30′	1′—9″	12′	Thinned once.
Nilambur (Madras) ..	1943	27′	1′	12′	2nd Rotation, 2nd Quality Nilambur thinned twice.
Kulsi (Assam) ..	1943	40′	1′—3″	6′	Not thinned.
Sagunpara (Assam) ..	1943	27′	1′—3″	12′	
Diphu (Assam) ..	1943	25′	1′—5″	..	
Jakhalabanda (Assam)..	1943	39′	1′—6″	9″	

FUEL PLANTATION

The growing of fuel plantations on waste lands on a commercial scale is an excellent proposition for private owners of land in Assam. In South India any piece of land unsuitable for the growth of food crops is put under Casuarina fuel plantation and the owners obtain good money returns after 10 years or so. Apart from Casuarina which thrives both in the coastal area as well as far inland on any poor sandy soil, such species as *Eucalyptus* and *Cassia siamea* are grown in suitable areas.

In Assam the planting of exotic species such as *Eucalyptus robusta*, *Eucalyptus globulus*, *Eucalyptus tereticornis*, *Cassia Siamea*, *Casuarino Montana* and *Homalium tomentosum* would probably give good results apart from local species like *Anthocephalus cadamba* (Kadam), *Macaranga denticulata* (Moralia), *Melia azedarach* (Ghora neem) and *Melia dubia* (Neem), *Vatica lanceoefolia* (Morhal), *Callicarpa Arborea* (Nagachali) *Albizzia lucida* (Maj), *Albizzia lebek* (Koroi), *Sapium baccatum* (Selleng), *Duabanga sonneratioides* (Khokan), *Tetrameles nudiflora*, (Bhelu), *Dillenia* species (Ou and baji-ou) *Gareya arborea* (Kumbhi), *Moringa pterygosperma* (Səjina), *Pongamia glabra* (Karach), *Ficus religiosa* (Ahot) *Ficus elastica* (Bar). Even quick growing hardwoods like *Terminalia myriocarpa* (Hollock), *Dalbargia sissoo* (sissoo), and *Tectona grandis* (T eak) can be grown. In every village and near most towns in Assam there are waste lands and the utilisation of them for growing fuel trees in a concentrated and intensive manner would both bring an added income to the people and would help to meet the shortage of fuel which is threatening all thickly populated centres.

Eucalyptus.—(*i*) Eucalyptus plantations are being raised by the Forest Department in the Shimoga District of Mysore for charcoal production for the Bhadravaty Iron Works, E. Citriodora being the main species used. The area has about 40'' rainfall, and an elevation of about 2,000'. In other parts of Mysore, where the rainfall is over 100" E. Robusta grows successfully, and this species will be more suitable for Assam conditions. It coppices readily and is a quick grower.

(*ii*) *Rotation*.—For the production of a fairly thick heartwood 26 billet (2½ in girth) a rotation of 15 years is thought to be suitable for Shimago. At present oldest plantation is about 10 years old.

(*iii*) *Planting technique*.—To minimise costs, sowing of seeds has replaced planting. Seed is sown on mounds prepared from pits dug beforehand at a specting of 6'—8'. Dehra Dun has recommended a reduced spacing to ensure quick sto cking.

(*iv*) *Thinning*.—One thinning in the 8th year is thought to be adeqate.

Casuarina Equisitifolia.—This is the main fuel species in Mysore State and South India, *Casuarina equisitifolia* being the main species used.

In dry, sandy areas a special technique for the growing of *Casuarina* has been evolved. After up-rooting all shrubs and lantan growth the area is thoroughly ploughed before the rains to conserve and retain moisture.

Planting of 6 months old seedlings in pits 6' apart is the method of propagation. The Nursery stock is pricked out in beds and the roots twisted slightly to encourage surface-rooting.

Costs.—This comes to some Rs.45 in the first year, excluding weedings, which cost Rs.8 per weeding.

Rotation.—It is expected that a suitable firewood billet can be obtained in 8 years. It is felt that *Casuarina montana* will be more suitable for Assam.

The Mysore Government has permitted their Forest Department to take up large tracts of waste land unfit for cultivation, for the growing of Casuarina as fuel for the larger towns. Tractors are employed to plough up the land where available and a fallow crop of gram (pulse) is planted as a fertiliser and to encourage the co-operation of villagers in the schemes.

The Forest Department in Assam is carrying out experiments in Sibsagar District on suitable quick growing species for fuel plantation in Assam. It is interested in methods of regenerating areas naturally by coppice and self-sown seeds, aided by sowing and planting where necessary. In this connection it is interesting to note the differences between burnt and un-burnt areas in the moister types of Forests, where the indications are that the stoking and growth is better if the area is left unburnt after felling.

On the grassy areas on the north bank of Brahmaputra it has been found that merely fire protecting patches of forests and assisting the plants by a little tending results in good stocking of such species as *Callicarpa arborea* (*Nagachali*), *Callicarpa macrophylla* (Tonglati), *Litseaea polyalthia* (Hingalu), *Careya arborea* (kumbhi), *Emblica offcinalis* (Amlakhi) etc.

Of the exotic fuel species which have been tried in Assam *Eucalyptus tereticornis* has given encouraging results at Rangapahar, the average height being about 12′ feet in a year. A small-scale fuel plantation of *Cassia siamea* has been started at Chakradeo near Azara. The Silviculturist is also carrying out experiments to find out the best methods of artificially raising the local fast-growing species such as *Macaranga denticulata* (Moralia), *Vatica lanceaefolia* (Morhal), *Melia azedarach* (Ghora neem), *Albizzia lucida* (Maj), *Anthocephalus cadamba* (Kadam), etc., and useful information with regard to their growing technique will be available in due course.

Shortage of fuel is being felt in almost all the towns of Assam even in some of the remote villages due to progressive clearance of tree forests in their neighbourhood. If early steps are not taken by private owners of land to grow fue species for meeting the demand of the growing population, and if unrestricted fellings of private forests is allowed to continue further, the time is not far when we will have to face the same situation as in Uttar Pardesh, where the peasants are compelled to burn their cowdung manure as fuel instead of diverting it to their field.

WATTLE PLANTATION
BY
M. L. SAIKIA

I. Scope :—

With the ban on import of South African Wattle bark and the shortage of other indigenous tanning materials such as *Cassia aurieulata* (Avaram) *Cassia fistula* (Sonaru), Myrobalans (Fruits of *Terminalia Checiula*) *Acacia arabica* (Babul) most of which occur sporadically and the cultivation of which has not been taken up, the need to cultivate species of Wattle such as *Acacia molissima* (Black wattle) *Acacia decurrens* (Green wattle), the barks of which contain comparatively higher percentage of tannin than other two species of wattle namely *Acacia dealbata* (Silver Wattle) and *Acacia pycnantha* (Golden Wattle), is urgent.

The following table shows the comparative tanning strength of wattle with other tanning materials.

Tanning materials	Percentage of tanning	Percentage of loss of tanning in infusion after 60 days
1. Divi divi *Caesalpinia digyna C. Coriaria*	40	29
2. Myrobalan *Terminalia chebula*	35	24
3. Wattle (*A. molissima*)	35	4
(*A. decurren*)	...	...
*(*A. dealbata*)	9—12	...
4. Avaram (*Cassia auriculata*) ...	16—6	...
5. Babul (*Acacia arabica*)	12 to 14	...

In Assam the following tanning materials are available but only Sonaru (*Cassia fistula*), Kuhir (*Bridelia retusa*), and Amlakhi (*Emblica officinalis*) occur in any quantity. The tannery in Gauhati is utilising Sonaru bark.

Tanning materials	Percentage of tanin
Sonaru (*Cassia fistula*)	12
Arjun (*Terminalia arjuna*)	20
Kuhir (*Bridelia retusa*)	16
Asna (*Terminalia tomentosa*)	15
Amlakhi (*Emblica officinalis*)	22

*Not recommended because of low tannin content.

The tanning industry in India has expanded to a great extent during the War years and the present annual requirement of Wattle bark has been estimated at 1 to 1 lakh tons, which if imported would cost two crores seventy five lakhs annually. When trade relationships with South Africa worsened the price of Wattle barks went up abnormally and by the end of 1949 the peak level of Rs.550 per ton had been reached.

Wattle bark is one of the richest vegetable tanning materials known and it is given the first preference over others by the tanners both in India and abroad. By the term Wattle generally four different species of Acacias are meant *viz Acacia mollissima* (Black Wattle) *Acacia decurrens* (Green Wattle) *Acacia dealbata* (Silver Wattle) *Acacia pycnantha* (Golden Wattle). Only Black Wattle and Green Wattle are cultivated to yield the wattle barks of commerce. Of these two species the former is considered better as the latter contains a small percentage of undesirable red and yellow colouring matter which gives the leather a poor colour, thereby reducing its value.

It is interesting to note that *Acacia dealbata* (Silver Wattle) was first introduced into the Nilgiris in South India sometime between 1840 and 1843 as a fast-growing fuel species and *Acacia mollissima* (Black Wattle) and *Acacia decurrens* (Green Wattle) were introduced a little later as shade trees in tea-estates. The importance of Wattle as a tanning materials was realised only about 15 years ago, when South Africa Wattle bark had become established in India. Wattle grows at elevations from 4,000′ to 7,000′ on well drained loamy soils deficient in limestone and with a rainfall of 60″ to 90″.

One species of Wattle (*A. dealbata*) is found fairly plentifully in the Shillong Hills but this species is not rich in tanning content. The Assam Forest Department has been experimenting with *Acacia mollissima* mainly and it has been found to grow excellently in the Kohima area and Shillong and is expected to do well in other hill areas of Assam. The tanning content of 2½ years old Wattle grown in Kohima is over 27 per cent., whereas that of South Indian wattle of the same age is not more than 17 per cent. The tanning content is expected to increase with age, so the prospects for wattle cultivation in the hills of Assam are very high.

In Assam variable results have been obtained by sowing and transplanting, the former being more successful in Shillong and the latter more successful in Kohima. In Bengal (Darjeeling) sowing is the method that has proved successful. Transplanting requires great care.

As a cash crop Wattle planting is an excellent proposition for the people of Hills as it can be grown in conjunction with potatoes and its use will serve three purposes, the production of tanning materials, the prevention of soil erosion, and the production of firewood and post timber.

2. History of Madras plantation :—

The first departmental Wattle plantation was started by the Madras Forest Department in 1937 with *Acacia decurrens* (Green Wattle) and by the end of 1947 the total area under plantation were 670 acres In 1950 the Madras Government sanctioned a Scheme to plant 6,000 acres on a ten-year rotation and the work is in progress. Besides, in 1948, 1,200 acres which was formerly under Pyrethrum cultivation were taken up for Wattle cultivation and upto the end of March 1951, 706 acres have been planted up.

3. Production Figures :—

On a 10-year's rotation, when stems 10″—12″ in diameter may be expected, a yield of 4—5 tons of bark per acre can be expected. In addition we can expect some 25 tons of fuel per acre from the stems. As Wattle can be grown along with

potatoes, and it is an excellent means of afforresting bare hill slopes thereby controlling erosion, it seems to be an ideal crop for private landowners in the Khasi and Jaintia Hills. Good results are obtained in conjunction with potatoes growing in the Nilgiris.

4. Planting technique :—

(*a*) *Pre-treatment of seeds.*—Wattle seed has a hard and tough testa, so it requires pre-treatment before sowing in order to obtain satisfactory germination. The pre-treatment consists in plunging the seeds into water (5 to 7 times the volume of seed) brought to the boil and left to cool for 12 hours, the seed is washed two or three times in clean cold water to rid it of the mucilage, and is then thoroughly dried in the air bofore being sown. Care should be taken to remove the fire from underneath before putting the seed into boiling water. Treated seeds remain viable for 6 months to a year.

(*b*) *Sowing in Nursery.*—It has been established by experiments in Madras that for uniform and proper development of the seedlings the quantity of seed sown per standard bed 40′×4′ should not exceed one pound. Such a bed will give 3,500 to 4,000 seedlings, but in the past on a nursery bed of 40′×4′ about 2 to 2½ lbs. treated seeds used to be sown. After sowing seeds should be covered lightly with well decomposed humus and watered daily with a fine rose-can. Germination usually starts in eight-day's time and is complete at the end of one month.

The treated seeds should be sown in the latter half of April so that it may germinate with the first pre-monsoon showers in May.

(*c*) *Preparation of soil.*—Soil working by digging or ploughing is advisable before planting as grasses and weeds seriously interfere with the growth of seedling at the initial stage. Wattle grown in association with crops of potatoes in South India is found to give significantly better height growth than those without potatoes, because of the intensive soil working in case of the former.

When wattle is grown in open grass lands without a crop of potatoes, pits 1′×1′×1′ are dug 11′ apart and the soil in the pits is thoroughly worked. Pits are dug six months before planting and the soil turned over to kill the weeds and grass roots. Another alternative method is to completely scrape the grass along the contours to a width of four feet alternating with unscraped strips 5′ feet wide in the centre of the scraped strips pits 1′×1′×1′ are dug 9′ feet apart, and the soil in the pit is thoroughly worked before sowing seeds in them.

(*d*) *Planting.*—Planting is done in pits prepared beforehand. One month before planting pits are refilled and 2 ounces of artificial manure is added ; the grass is scraped away from around the pits for 2′ ft. all round. Sowing of 4-5 seeds per pits is also recommended as an alternative to planting.

In Natal (South Africa) the method of propagation is by sowing in strips 6′—7′ apart with wind belts at intervals. Dense sowing is avoided on account of root competition.

(*e*) *Manuring.*—Manuring is beneficial when Wattle is grown for afforesting open grass lands. In South Africa super phosphate at the rate of 200 to 400 pounds per acre in case of line-sowings are generally used and wattle plants thus manured are reported to yield 15 to 40 per cent. more bark than those unmanured. In South India the use of 2 ounces (half a cigarette tinful) of potato fertiliser containing 12 to 14 per cent. Nitrogen, 8 per cent. Potash and 6 to 9 per cent. phosphates is reported to have given significant increase in height growth in the early stages.

(*f*) *Espacement.*—Various espacement from 3′×3′ to 16′×16′ were tried in South India but 12′×12′ espacement is found to give the best height growth and diameter increment. But in areas susceptible to wind damage initial espacement of 9′×9′ is recommended and during the 2nd or 3rd year the espacement should be reduced to 12′×12′.

(*g*) *Weeding.*- The rate of growth of wattle being very slow during the 1st year or so it cannot stand competition from weeds and grasses. So regular weedings 2 to 3 times during the first year is necessary. This is done by hoeing up the soil, emphasis being placed on avoiding injury to the spreading roots, the dangerous stage is reached at 6' ft height. Wattle is a quick grower in later stages and is intolerant of shade. Early planting results in quick establishment before the heavy rains. Weeding may be necessary in the 2nd year in areas where weed growth is heavy.

(*h*) *Prunning and thinning.*- Heavy prunning is to be avoided and should be confined to double leaders and vigorous stool shoots only, and in the winter months. Wattle is a very strong light demander and from the very beginning it cannot stand lateral or over-head shade, so early thinnings are recommended. Vigorous plantations may be reduced to 250 300 stems per acre by early and heavy thinning by the 3rd year and thereafter thinning should be light and infrequent ; less vigorous plantations should suitably be reduced to 400 to 450 trees per acre. Under thinned and congested wattle does not response to subsequent thinning.

5. Injuries to which the crop is liable :

Frost, Fire and Grazing- Wattle is sensitive to all these three factors. It is also sensitive to strong winds. Seedlings are very tender to frost till they reach a height of 2' to 3' and frost cover should be provided during the 1st and 2nd year. Young Wattle seedlings are very sensitive to fire and strict fire protection is necessary during the 1st 5 years. Grazing by domestic cattle causes considerable damage to young seedlings.

"*Gummosis*" or bleeding is an obscure pathological condition of very wide occurrence. Exudation of gum from the boles of trees and black mottling of the bark can be seen in older plantations, six years and above. It is said that the disease can be controlled to a great extent by following sound Silvicultural principles, such as timely and regular thinning. The affected barks becomes dry, brittle, and useless and they should be removed immediately.

6. Harvesting :-

At approximately 10 years or when the tanning content in the bark and the quantity of bark per acre are at their maximum, the trees are cut down and chopped into 5' lengths and bark stripped and sent to the tanneries. The lengthening of the rotation may be justifiable if the trees maintain of growth even after 10 years.

7. Drying and processing the bark :-

The bark may be disposed of either green or dry, depending upon the proximity of the wattle extract manufacturing facilities. Wattle bark is dried usually by spreading out on brush wood or on poles, with the outer surface kept uppermost, as this method helps in shedding water from barks. Care should be taken not to expose the undersurface of the bark to the sun in order to avoid bad discolourisation. During rainy weather specially constructed driers with arrangement for circulation of hot air from an oven are necessary.

Mildew attack is generally noticed when barks are heaped up or kept bundled together and special care is necessary to avoid creation of such conditions favourable for mildew attack. The drying is complete when the bark becomes brittle and light brown in colour. The dry bark is chipped into lengths 6" to 9" or made into chips about 2" - 2" and pressed into bales or packed in bags for disposal.

8. Financial aspect of wattle cultivation (based on wattle cultivation in Madras) :

(i) The pre-war price of wattle bark in Madras varied from Rs.120 to Rs.160 per ton though the war time price was Rs.550 per ton. It is safer to base our calculation on the pre-war price on the assumption

that the price of Wattle is not likely to fall below this price. The average bark being 5 tons per acre and yield of firewood 25 tons per acre, a revenue of Rs. $(5 \times 140 + 25 \times 10)$ = Rs.950 per acre may be expected.

(*ii*) The formation cost by direct showing method has been estimated at Rs.64 per acre and by the transplanting method the cost will be less.

(*iii*) The exploitation cost of bark and firewood has been estimated as Rs.349 per acre, the total expenditure thus being (Rs.349+Rs.64)= Rs.413, and a net return of (Rs.950—Rs.413)=Rs.537 per acre at the end of 10 years.

9. Varieties aad their hybridization problem:—

Acacia decurrens (Green wattle) is faster growing and more frost hardy than *Acacia mollissima* (Black wattle) and can grow in drier areas. Though it is faster growing it has a thinner bark than Black wattle and about the same tannin content(the average yield is the same for both the species). The bark of green wattle imparts a red colour to leather for which it is disliked by the tanneri. The seeds of Green wattle though smaller ripen with 4 months of flowering as compared to Black wattle which takes 14 months to ripen. It has also a higher germination percentage and gives a greater volume of timber.

Where several wattles grow together, as in the Nilgiris, the time of flowering is important from the point of view of the possibility of hybridisation affecting adversely the tanning content of the bark. As already mentioned earlier, the tannin content of *Acacia-dealbata* (Silver wattle) is 8—12 per cent. only and it serves as a cheap source of firewood. The species has run wild in the Nilgiris and has the advantage of spreading rapidly by means of the root suckers. The species flowers more or less at the same time as *Acacia mollissima* (Black wattle) and there is every possibility of hybridisation and consequent reduction of the tannin content of *Acacia mollissima*, which is about 35 per cent. on the average. It is therefore esssential to ensure pure strains of the highest yielding species. While a hybrid between *Acacia dealbata* and *Acacia mollissima* is undersirable for the above reason, it will be quite suitable to evolve a hybrid between *Acacia decurrens* and *Acacia mollissima*, therby securing the hardiness and fast growth of the former without its underdesirable red colouring matter.

The Shillong area has the advantage over the Nilgiris in this respect as the inferior wattle (*Acacia dealbata*) is not very plentiful and it can be eradicated where and when commercial cultivation of Wattle (*Acacia mollissima*) is taken up

To conclude, the importance of a steady supply of high-grade tannin material in the development of the leather industry in India and in Assam cannot be over-emphasised. With the rising of the standard of living in India and the abundant supply of skins large quantities of which are now exported, the prospects for a flourishing leather tanning industry within Assam are bright. Several States are making efforts to raise wattle plantations with less favourable natural advantages than Assam possesses, and it is upto the people of the hills of this State to take to this profitable occupation.

SAW MILLS

In the days before plywood was invented there were a number of saw-mills in Upper Assam producing tea-shooks or planks for tea-boxes from Simul, but the last of these mills closed down in the twenties with the advent of the imported Veneer panel and the opening of the Margherita and Murkongsellek Veneer Mills, and to-day Simul is reserved exclusively for the Match Industry.

The last war saw a revival of Saw-Mills for the conversion of miscellaneous hardwood timber for the war-effort and subsequently for sleepers, constructional timber, and soft-woods for the packing case industry. Since the war, there has been a tremendous rush to start saw-mills by private parties all over Assam and in some cases mills have been located without planning and consideration for continuous supplies of timber.

There is admittedly scope for the great employment of saw-mills in Assam to-day, with the emphasis swinging from the utilisation of a few durable species only to the conversion and utilisation of many less popular and durable timbers, this change has been brought about by the growing scarcity of the former species and the greater demands for timber as a whole. The demand in the Calcutta market for packing-cases material also has made possible the utilisation of inferior species. But if the Assam saw-milling industry is to develop on sound lines, there are certain obvious facts which have to be borne in mind.

The first consideration is the location of the saw-mill. Hitherto the generally accepted principle has been that a mill should be sited as near as possible to the forests from which it draws its raw material. This is generally true, but where the lines of extraction are good, transport is cheap and electric power and good markets exist in a town for all the bye-products and wastes from sawing, a saw-mill may with advantage be located in or near a town and comparatively far from its raw materials. Added advantages in such cases are the availability of intelligent skilled labour, who may not require special housing and the greater facilities of sanitation and medical aid. To-day large logs are being brought many miles from the forests to small electrically driven saw-mills in Tezpur and Nowgong with success.

Another important consideration is the type of machinery to be installed. While it is essential to have band-saws, particularly horizontal band-saws for the conversion of the large logs we get in Assam, the installing of a large circular saw which is more robust than a band-saw and very useful and economical in breaking down logs, is essential. The single bench-mill situated in the forest is sure to be a failure, though in a town they can succeed. The best type of mill is the two-bench mill with a circular saw. Such a mill ensures the maximum output, which need not be more than 10 tons per day though few mills are able to sustain this output at a steady level for long.

The third, and in some respects most important consideration, is the portability of the mill. While it is true to say that the true portable mill has not yet been invented, much can be achieved by having the simplest equipment.

This latter point is very important, as the forests that await exploitation in Assam are mostly in the interior and of poor stocking in respect of utilisable and saleable species, and if saw mills are to be used they must be capable of being shifted from place to place after a few years, and that over poor communication lines. Hence the emphasis should be on lightness and portability, and the employment of Diesel engine power instead of steam power.

Another important consideration is efficiency of extraction methods, which has a direct bearing on the profits to be derived from saw milling In Assam there is very great lee-way to be made up in this respect :—prompt and maximum extraction of logs by the cheapest and most efficient means of transport should be the first aim of all saw-millers. But at present the time-lag between the felling of the tree and the arrival of the log at the mill is considerable, resulting in much loss of timber through fungus-attack, while a percentage of logs invariably

totally lost through delayed extraction ; untimely rains and poor communications are the main causes of this generally but very often the saw-miller is to blame for dilatory working and insufficient extraction machinery such as elephants and motor trucks.

An example of an efficient timber industry is that located on the west coast of India of which Calicut is the centre. There are said to be more than 30 Saw mills in the town and the Kallai river presents the aspect of an industrial city with its numerous saw-mills, chimneys and sheds and rafts of logs moored continuously along the banks. The town is well situated to receive timber from the rich Nambur and Wynnad Forests by river to export finished timber by sea to the Arabian sea coast, Bombay and Karachi, and by train to Madras, Bangalore and other places in South India. Although no saw-mills are given leases of forests, as is often the case in Assam and all timber is to be purchased in the form of coupes or in the open market, the industry is a thriving one. Log prices vary in Calicut from Rs.2-8-0 per c.ft. for softwood to Rs.4 per c.ft , for hard-woods, and price of sawn timber *ex*-mills are Rs.3-8-0 to Rs.4 for softwoods and Rs.6 to Rs.7 for hard woods. These may be sold in Bangalore, a central point in South India after being transported 300 miles by rail, at Rs.5 to Rs.10 per cft. Sawing charges are annas 9 to annas 12 per c.ft. *plus* annas 2 for planks. When it is remembered moreover that logs have to be floated considerable distances by river to the mills and purchased in competition with others, the finely balanced nature of the industry can be realised. The emphasis is on small profits and quick returns, and there is no fear of long leads, while extraction of everything saleable is the practice, unlike in Assam where much small logs and branch-wood are left behind. Another reason why the trade can function with highly efficient imported machinery, for instance the South India Saw Mills which has an output of 30 tons per diem, has no less than 6 band-saws (2 of them being new), 12 circular saws and a modern boiler, burning wood and saw dust.

An example of a Government Saw Mill is the Siliguri Saw Mill owned by the West Bengal Forest Department. The main features are :—

I. *Machinery.*—

3 Band Saws—(one is generally idle for repairs, etc. Blade changed every two hours).

5 Edhers.

3 Cross-cut saws.

4 Boilers, (burning wood fuel and waste).

1 Overhead Electric Crane.

II. *Outturn.*—30 tons per day or 6,000 tons per annum (3,00,000 c.ft.).

III. *Wastage.*—20 per cent. on average. Weekly check of wastage by clearing the "deck" on Saturdays is 20 per cent

IV. *Costs.*—(per c.ft.)

	Rs.	a.	p.
1. Log extraction upto Siliguri Sawmills ...	0	8	0
2. Milling expenditure (including pay of Subdivisional Officer, Assistant Manager, Deputy Ranger, Forester, Mill-Staff, running costs and depreciation charges).	0	8	6
3. Royalty 12 annas per c.ft. in round and wastage	1	1	0
Total ...	2	1	6

V. *Average expenditure*—(per c.ft.)

	Rs.	a.	p.
1. For all species	2	2	5
2. For Teak	2	13	0
3. For Sal	2	5	6
4. For 'B' Class	2	0	8
5. For 'C' Class	1	13	6
6. For 'D' Class	1	11	10

VI. *Selling Price*—(per cft.)

1. Average for all species	2	15	10
2. Teak	4	15	11
3. Sal	3	6	4
4. 'B' Class	3	1	9
5. 'C' Class	2	6	4
6. 'D' Class	2	6	4

VII. *Actual Profit*—Rs.2,55,000 in 1945-46.

VIII. Auctions are held periodically of all surplus stocks not specifically ordered.

IX. The Mill is run by two Forest Rangers, one Deputy Ranger, one Forester, one Mill Foreman and other necessary hands.

The Assam Forest Department has for some years now run a semi-departmental sawmill at Rangapahar near Dimapore, which was brought into existence during the war to supply the army with timber. The mill machinery is owned by a contractor who is paid at varying rates for conversion of the timber which remains the property of the Department. The extraction side of the operation is run entirely by the Forest Department with hired elephants and a fleet of motor trucks. Working costs average as follows.—

Hard wood :—

(A) *First Operation*—

	Rs.	a.	p.	
1. Felling and logging	3	8	0	per ton.
2. Primary extraction	8	0	0	,, ,,
3. Secondary extraction	12	8	0	,, ,,
4. Road making, Camp, construction, etc. ...	12	0	0	,, ,,
Total ...	36	8	0	per ton.

(*B*) *Milling*—

1. Taking 30 per cent. less in conversion cost of sawn timber.	48	0	0	per ton.
2. Average Sawing charges 25 per cent. scantlings, 75 per cent Planks.	53	0	0	,, ,,
3. Handling charges	3	0	0	,, ,,
Production cost of 'B' Class timber	104	0	0	per ton
Royalty	43	12	0	,, ,,
Add 5 per cent. ultimate rejection	7	6	0	,, ,,
	155	2	0	per ton.

i. e. Rs.3-2-0 per c.ft. Rs.3-4-0 per c.ft., with sale tax.

For 'C' Class Timber (Rs.104+Rs.31-4-0+Rs.6-12-0=Rs.142), *i.e.*, Rs.3 per c.ft.

'D' Class Timber (Rs.104+Rs.21-14-0+Rs.6-4-0=Rs.132-2-0), *i. e.*, Rs.2-13-0 per c.ft.

'E' Class Timber (Rs.104+Rs.14-1-0+Rs.6-0-0=Rs.124-1-0), *i.e.*, Rs.2-10-0 per c.ft.

Softwood

Cost of production of Bhelu Flitches 6″ and up × 8′ and up × 6′ and up.

		Rs.	a.	p.	
1. Cost of production of Sawn timbers estimated at 30 per cent. less will be.—		48	0	0	per ton.
2. Sawing charge ...	...	31	4	0	,, ,,
3. Handling charges ...	...	3	0	0	,, ,,
Total	...	82	4	0	per ton.
Royalty 'D' Class ...	...	21	14	0	,, ,,
Add 5 per cent. final rejection ...	...	5	3	0	,, ,,
Total	...	109	5	0	per ton.
	, *i.e.*,	2	3	0	per c.ft.*

VENEER MILLS

Prior to the last war there were really speaking only 2 veneer mills in Assam, one at Margherita and the other at Murkongsellek, both European owned concerns and among the oldest and largest factories of their kind in India. Since the war, however, there has been a great demand for opening factories in Assam, consequent on the protection given to the industry from foreign tea-chests. In Calcutta very many mills mostly with Indian made machinery have come into existence, but are managing with difficulty owing to the shortage of timber. In Assam there is no dearth of timber suitable for veneers, no less than 20 varieties being available, though only 3 or 4 are found in such concentrated quantities as to justify a unit being based exclusively on them.

Other things being equal the larger a veneer unit, the more economical it is in the long run. An output of 6,00,000 tea-chests per annum should be the target for a really economic unit, but such a plant would require a supply of 3,00,000 cft or 600 tons of timber per annum, and there are few blocks of forest left in Assam capable of meeting such a demand of the one species. Such a large plant would, moreover, involve a capital expenditure of at least 15 lakhs of rupees. In India today there are only a few plants of this size. In addition to the two plants mentioned above, there are the Western India Plywood Company at Baliapatam near Cannanore on the West Coast of India and the Mysore Plywoods Corporation in Bangalore.

* NOTE—The above rates do not include the pay of permanent Staff, which is payable by a private saw mill in the shape of a manager, clerks, etc.

Another important condition is the location of the plant as close as possible to the source of the most important raw-material, timber. In this respect the two large Assam plants at Margherita and Murkongsellek are ideally situated, as also the Baliapatam factory which is positioned to receive its timber-supplies from the rich Wynaad forests, mainly by river. The Bangalore Mill is however not well situated for its timber supplies which have to come from the Mysore forests a distance of over 140 miles by road and rail, and the only reasons why the plant continues to be located at Bangalore are the marketting conveniences for distribution of its finished products, the availability of plentiful and intelligent labour, and the fact that cheap electrical power and a ready factory-site were originally available. Even so, the low delivery costs of logs (Rs.2 per cft.) at factory site is only possible because the company have a lease of forest from the Mysore Government at very favourable terms paying a royalty of only 1 anna per cft. (This is to be compared with the royalties of about 5 annas per cft. paid by the Margherita and Murkongsellek mills in Assam for their supplies of Hollong and Hollock respectively).

In Assam there are two small plywood units located in Dibrugarh and Gauhati based on Hollong (Dipterocarpus macrocarpus) and Gogra (Schima wallichii) but they are also suffering for ack of sufficient timber which has to be brought considerable distances by road or rail.

Most plywood-Units in Assam seek long-term leases of forests, and there is no doubt that for satisfactory planning and economical working such leases are necessary. But it is often found that the giving of a monopoly working right over a particular area to a company for one particular purpose, such as the manufacture of veneers, tends to hamper the exploitation of the forests in a balanced manner for other species or forest produce, and the present policy is for the Forest Department to arrange supply of a mill's requirements from the annual coupes through its contractors.

The type of machinery installed in a plywood unit is of importance, and there is no doubt that the more reliable, efficient and durable machines for the various processes of making plywood can, at present, be only obtained from Europe or America. The selection of suitable makes of Peeling Machines, Driers and Presses is of utmost importance if the factory is being planned with a view to the future and for maximum efficiency and profit, and it is not advisable to insist on initial economy in these respects. The Mysore Plywoods Corporation, Bangalore, which has probably the most up-to-date and efficient plant in India to-day, each machine having been individually selected for its efficiency for the particular task it has to do, has the following makets represented in its plant :—

List of Veneer Machinery in Mysore Plywoods Corporation Ltd. :—

1. Coe Veneer Cutting lathe. (Electrically driven—can cut logs upto 100" long and 60" in diameter. This machine cuts veneers from 1/500" to 2/5" thick).
2. John Pickles horizontal Slicer (takes logs upto 10 ft. in length and slices. Veneers from 1/16" to 1/100" thick).
3. Coe Veneer Dryer (Steam heated which dries veneers from 5 to 15 minutes according to the thickness of the veneer).
4. Diehl Veneer Jointer.
5. Diehl Veneer Splicer (joins veneer edge to edge).
6. Columbia Hydraulic Press (Steam heated—pressed plywood up to 8'x4' sizes mainly used for resin-bonded plywood).
7. Solem Four Drum Sanding machine (Sands the Plywood to a uniform smooth finish).

Besides veneer machinery the company has a complete wood working plant to fabricate doors and window frames, railway-coach components, radio-cabinets, etc.

Most plywood units in Assam still use casein glues, but the two South Indian units have set an example by using synthetic resin-glues, and there is great scope for experimentation with modern glues. Moreover, the production of commercial and decorative veneers is still in its infancy in Assam, the two large companies preferring to stick almost entirely to manufacturing tea-chest veneers from one or two species only. But there is no doubt that there is great scope for the utilisation of the wealth of plywood species found in Assam for the manufacture of commercial and decorative veneers and by employing the various modern techniques This subject is treated more fully in the chapter on Processed Wood. But apart from this, it is felt that the modern veneer mill is not complete without a saw mill and wood-working shop for the utilisation of waste and inferior material, non-veneer species, etc., while the installation of a timber seasoning and treating plant is also desirable. Future veneer mills in Assam must depart from the routine manufacture of tea-boxes and expand their scope in the above directions if they are to pay their way and succeed in the present set-up of shrinking supplies of the popular veneer-woods and the modern demand for other products. They must also be prepared to utilise a veriety of species, as there are very few areas left where one species is found growing gregariously in sufficient quantity. The usual practice in such cases, is to employ one species as a core veneer and another for the face-veneers. Minor modifications in technique, so far as drying, glueing, and seosoning, may be necessary.

PROCESSED WOOD

The essence of processed wood is its economy of material and the utilisation of inferior timbers and waste-products of the timber industries.

Apart from veneers, which are the most commonly known form of processed wood, there is an increasing variety of forms of 'glued-wood' products, such as laminated wood, molded plywood, and composite-wood as well as 'modified wood', products such as resin-impregnated wood (Impreg and Compreg), heat-stabilised compressed wood (Staypak) and urea—plasticised material (Ural loy).

All these products have been made possible by the advances made in adhesives and glueing technique. The introduction of synthetic resin adhesives such as resorcinal, phenol-resorcinal and melamine, and the improvement of techniques for applying and setting them which received a definite impetus during the last World War, are mainly responsible for the progress made. In India a cold-setting phenolic adhesive has been prepared from oil extracted from the cashew-nut and this is of importance in view of the search for durable and weather resistant adhesives for Indian conditions.

1. *Glued-wood products.*—Laminated structural units such as beams, arches, and rafters, prefabricated and assembled on the spot, have essentially the same properties as solid wood and have the advantage that they are no longer restricted in size or shape. Their design makes possible the use of low-grade and small-sized timber for the interior laminations which moreover can be relatively rapidly and efficiently seasoned Smaller units suitable for turnery work are also possible, while components for automobile bodies, airplane parts, furnitures sports-goods, shoe-lasts, etc., can be turned out. The application of electrostatic heating for the setting of the resin glues is a significant development.

Molded Plywood or the production of curved shapes in veneers, the foremost examples of which in the last war were the construction of Mosquito bombers, gliders, and torpedo-boats, is another advance made possible by the development of new and improved adhesives and the stimulus of war-time design.

Composite wood, or 'sandwich' construction, in which wood, pulp-board, or other light weight filler substances are surfaced with durable materials such as metal, plywood, or resin-impregnated compressed wood, is another recent development. The bonding of metal and plastics to wood to form composite

units which take advantages of the best qualities of each material and provide, a product superior to any single one of the bonded materials, is the latest advance and one which has great promise towards the improving of appearance and serviceability of low-grade plywood.

2. *Modified wood.*—This is the result of the modern application of synthetic resins and urea to wood and the compression of both treated and untreated material under certain conditions.

Impregnated wood consists of veneers from 0·1 to 0·3 m.m. thick impregnated with an alcholoic solution of phenolic resin and pressed under heat.

'Compreg' is a compressed and densified form of resin-impregnated wood which is water, acid and decay résistant, free from shrinking and swelling and capable of being molded into various shapes. Compreg has been made into aircraft propellers, bearings, gears, rollers, etc.

A somewhat similar product, 'papreg' is a plastic-like paper laminate of high tensile strength made upof thin sheets of special types of paper impregnated with synthetic resin, which canbe pressed into sheets or molded. Paper laminates treated with phenolic resins are of use as electrical insulating panels and for other purposes where high strength properties are not required.

Lignin Plastic is made from wood waste such as shavings and powder. Hard-boards can be made from saw dust with a small percentage of ground-nut protein-resin binder, while mixing wood-wool or shavings with inorganic binders like portland cement produced boards of the 'Heraklith' type. Building-boards can even be made from the bark of trees.

All the above products have their basis on the veneer or '3-Ply' industry. At present Assam as veneer mills making only veneer panels for tea chests from peeled veneers with casein glues. No commercial veneers (which are large panels, made up of several layers of veneers suitable for panelling, bus-floors and bodies, etc.) or decorative veneers (which are comparatively large panels made up from sliced veneers, where the log is sliced across the gràin into thin sheets instead of being peeled, whereby beautiful figure effects are contained) are produced, while the use of modern glues is unknown. There is no doubt that this conservative attitude towards veneers must give place to a more enterprising endeavour to make full use of Assam's wealth of veneer timbers, which are over 20 in number, to meet modern demands.

TREATED WOOD

1. *General.*—Assam has a variety of timber species mostly of a moderate hardness and durability, and high moisture and humidity conditions which encourage the rapid growth of wood-destroying fungi. It is therefore particularly necessary that there should be considerable employment of preservative-treated timber in all structural works. But except for the Railways, who use a certain quantity of treated sleepers and some of the Tea Gardens, and the Assam Oil Company, who use their own oil preservative, there is very little utilisation of treated timber nor is there much knowledge about it. The main reason for this has been the hitherto plentiful availability of cheap timber for those who use timber as such and of bamboos, reeds, thatching-grass, etc., for the poorer classes whose consumption of timber is very small. But there are signs that the supples of good quality constructional timber are unable to meet the demands with tihe rapid opening up of the country and the greater progress of industrialisation and it is expected that one section of the timber using public at least will take readily to the idea of using treated wood of hitherto neglected species instead of non-durable timber even at a slightly higher initial cost. At present creosote crude oil treated timber is available for the private consumer from the Naharkatiya Sleeper Treatment Plant at about Rs.2 more than untreated timber.

There has been for the past 15 to 20 years the nucleus of a timber treatment industry in Upper Assam in the shape of the railway owned sleeper treatment plant at Naharkatiya, the Assam Oil Company's plant at Digboi and the A. R. and T. Co.'s plant at Margherita, but the first has concentrated entirely on treatment of sleepers and the two latter have been utilised mainly for treatment of private requirements and those of constituent tea-gardens. Both the Railway and the Margherita plants are among the best of their kind in India to-day and provided the demand is there can meet the requirements of the large tea industry of Upper Assam which has, hitherto, relied entirely on steel or untreated timber. With the demand for better housing for labour there seems scope for the greater utilisation of some of the less popular timbers in the treated condition, provided of course that their structural qualities are satisfactory. But these plants are being sent from stations in Lakhimpur.

2. *Oil Preservatives.*—Among the oil preservatives, coal-tar creosote is mainly used, the heavier the creosote the more permanent being the action. Mixtures of creosote with fuel oil in the proportion of 75 :25 or 50 :50 give the best results and allows for latitude in the selection of creosote specifications. For Assam conditions a final absorption of 5 to 7 lbs. of preservative per cubic foot of timber is considered adequate. A creosote-based preservative which can be applied by brush-painting is *Solignum* which is marketted in India.

The Naharkatiya and Margherita plants employ creosote and crude oil in the proportions of 50 :50, under pressure, and the timber so treated is particularly suited for use in outdoor locations and in a country like Assam, owing to the resistance of oil to the 'leeching out' effects of moisture and the high degree of toxicity of creosote to fungus and insects. As an example of what can be achieved with this treatment, a set of poles of Morhal (*Vatica lancaefolia*), a fourth class species of no natural durability, treated in 1932 and used for a bazar-shed in Jaipur, are in a complete state of preservation to-day, after 20 years, in a white-ant and fungus infested locality. Sleepers of miscellaneous species such as Hollong (*Dipterocarpus macrocarpus*) and Jutuli (*Altingia excelsa*) whose normal life untreated would not be more than 4 or 5 years, have lasted as long as 18 years in the main line and have been removed only because the spike-holes became worn and not because of any decay of the timber. Without treatment the average life for sleepers of Sal (*Shorea robusta*) is sixteen years, for Nahor (*Mesua ferrea*) it is thirteen years, and for Hollock (*Terminalia myriocarpa*) it is five to six years.

The cost of treatment at Naharkatiya is Rs.1-7-0 per cft., to which must be added about 9 annas per cft., on account of railing, unloading, handling and re-loading in the event of timber being sent from stations in Lakhimpur District to Naharkatiya. Treated timber is available from the Forest Department at Naharkatiya at Rs. 7 to Rs.8 per cft.

In the application of the creosote-crude oil pressure treatment, various modifications of the basic principle are employed such as the Boulton process, the Lowry and Rueping empty-cell processes, and the Bethel full-cell process, according to circumstances and necessity. Fundamentally the treatment aims at the replacement of the air in the cells of the wood with the preservative, and its retention therein in varying degree. The preliminary air seasoning or drying prior to the treatment has as its object the reduction to a minimum of the amount of moisture in the wood, and in the case of Hollong sleepers a period of 3 to 6 months in open stacking is required for this. In all cases it is essential that proper care is taken at the time of conversion of the timber in the forest to ensure that only sound logs are utilised. Moreover extraction should be rapidly done and the timber should not be permitted to lie about in unhygienic surroundings favourable to fungus growth as once it is infected with fungus the effect of the preservative is lost.

The Boulton process consists of "boiling under vacuum" and is employed when the timber has not been sufficiently air-dried. The timber is placed in the treatment cylinder and the preservative oil is admitted and its temparature raised to 180° F while a vacuum of 20″ is gradually applied. Evaporation of moisture from the cells of the wood takes place and partial penetration of the cells by the oil results. The period required depends on the desired moisture content of the wood. Samples of the wood before the treatment are taken with Presslers' borer and the moisture content determined by weighment both before and after heating to 100° C: as the volume of the charge of timber in the cylinder is known, the amount of moisture to be drawn off in the form of water in order to obtain the desired condition as regards residual moisture—content can be determined beforehand and the treatment lasts until this is achieved.

The Boulton processes is rather drastic due to the high temperature and the vacuum employed, and there is a possibility though remote, that the strength of the cell-walls may be impaired. The best arrangement is to season (air-dry) the timber for 3 to 6 months and then apply the Bethell 'full-cell' processes, the Lowry or the Rueping. The Lowry process gives good penetration but moderate retention, and so is generally preferable to the Bethell process, which is expensive, or to the Rueping, which gives the least retention of oil and so under Assam conditions may not provide sufficient protection. In the Bethell process preliminary vacuum of 22″ is created and maintained for 1½ hours, after which the cylinder is completely filled, the temperature raised, and a pressure of 180-200 lbs. applied and maintained while more oil is forced in until the desired absorption is obtained or virtual refusal to absorb more the pressure is then released and a small vacuum of 20″ for an hour or so is applied to remove the surplus oil.

The Lowry process is the same as the Boulton except that when the desired moisture content is achieved the vacuum is removed and oil is pumped out of the cylinder to restore the atmospheric conditions ; oil is then pumped in again and a pressure upto 180 lbs. is applied and when no further retention is possible the oil is pumped out and vacuum applied to almost empty the cells.

The Rueping process differs from the Lowry in that instead of atmospheric pressure a higher pressure of 50 lbs. per square inch is applied initially before admitting the oil. This results in maximum recovery of the oil and least retention.

3. *Water-borne Preservatives.*—Besides oil-preservatives, there are several water-borne preservatives being marketted under various names, such as Wolman's Salt (Tamalith brand), Celcure, Boliden salts, Copper Napthanate, etc. A now well known preservative which was developed in India is "ASCU" a combination of Arsenic Pentoxide, Copper Sulphate and Potassium Dichromate in the proportion of 1 : 2 : 3 dissolved in water. In commercial applications of water-borne preservatives the concentration of the treating colution can be altered to suit the permeability of the wood being treated. Water-borne preservatives can be applied by brushing, dipping, or under pressure. In Assam with its high rainfall which has a leeching effect on wood, the pressure treatment would be preferable. An ideal combination for structural work of all kinds would be the use of Ascu or other water-borne preservative for indoor locations, and of creosote-oil mixture for outdoor locations. The same pressure cylinder can be used for both types of preservatives, necessitating only its cleaning after the oily type has been used and before the water-borne preservative is introduced, or separate pressure cylinders can be maintained. The cost of a plant for treatment with "Ascu" is very reasonable and the patentees, the Well Wood Roof and Bridge Structures, 4-Miller Road, Bangalore are prepared to supply a "Century" Ascu Treating Unit for Rs.15,000 F. O. R. Bangalore. A smaller portable plant called "Simplex" capable of being transported to a site of work is available for Rs.5,000.

In selecting a particular preservative for use due regard must be paid to its cost, availability and suitability for the particular purpose. There is danger in employing a preservative which is not produced within the country, as in case of war, supplies may be cut off. India produces plenty of creosote and as a matter of fact production of this preservative is in excess of demands, while it is expected that Arsenic Pentoxide which is the only constituent of "Ascu" imported into the country will soon be produced in India.

As an example of a Wood Preservation Plant the Mysore Government installation at Bhadravati may be cited. This plant was installed in 1928 and has proved its value since then. From 1928 to 1936 the treatment was with a mixture of Diesel oil and Wood-tar Creosote which was a bye-product of the wood-distillation plant which produced charcoal for the Bhadravati Iron Works but when this was abandoned in favour of charcoal made by ordinary burning in the forests, coal-tar creosote came to be employed. Later on from 1936 "Ascu" became the standard preservative in strengths of 6 per cent. which was subsequently raised to 8 per cent.

The plant consists of the following machinery :—

1. A treating Retort 45 feet long and 5 feet in diameter with hinged doors at each end, a vapour drum, a condenser, and a set of meter-gauge rails running throughout the length of the retort.
2. Two lower Services Tanks or Preservative Tanks with a capacity of 4,200 gallon each, 22′—6″ & 6′×5″, mild steel.
3. One Vacuum pump.
4. Two Pressure Pumps (200 lbs. pressure).
5. One cross tube Vertical Boiler of 20 H.P. for generation of steam to work the pump.
6. One Rueping Process Tank of 30 feet long and 5 feet diameter.
7. Valves, steam coils, pipes and connections, pressure and temperature recorder, etc.
8 One ton Crane on rails.
9. One Winch, for hauling charges into cylinder.
10. One Portable Electric Drill.
11. Fourteen Trucks.

Up-to-date the capital expenditure on the plant including buildings and permanent way has been Rs.1,21,800. The main work is treatment of Mysore Government timber, Dhuna (*Dipterocarpus indicus*) being used for sleepers and Balagi (*Pœciloneuron indicum*) for electric transmission poles. The Bethell 'full cell' process is employed. The timber to be treated is loaded on the required number of trucks and introduced into the cylinder (a full charge is generally about 300 c.ft.) and the hinged doors are closed airtight by means of the heavy bolts at the rim of the cylinder. An initial vacuum of 22 inches is created with the vacuum pump for half an hour and the preservative solutions is then admitted and the pressure raised to 125-175 lbs. per square inch. A final vacuum to 'dry' the wood is then applied. The whole process takes about 3½ to 4 hours. For outside locations a minimum concentration of 8 per cent. Ascu in water and a final retention of not less than 7 to 8 lbs. per c.ft. uniformly distributed is the aim. Treatment is of a high standard, and specifications are rigid, rejections being severe. All adzing, boring and jointing are done before treatment. The best and most economical results are obtained with seasoned material in which moisture content has been reduced to 20 per cent. After treatment the timber is kept under shade to prevent cracking and splitting. Absorption is proportionate to the amount of sap-wood and the size of the material, being greater in timber of small cross section or where the surface area is maximum. It has been found that increasing concentration of the chemicals in the solution results with progressive treatments, either by selective absorption by dilution from the moisture present in the wood or by individual re-actions of different timbers, but this can be rectified by testing and adding the necessary chemical which is found short. Sludge collects at the bottom of the tank, but no serious corrosion takes place. Sludge analysis show Arsenic 28 per cent. Chromium Oxide 11 per cent., Copper 3 per cent. and iron 22 per cent. Fresh Ascu solution is to be prepared after about every 9 charges when the quantity of liquid has been reduced to a cylinder full ; 2,600 gallons of fresh 8 per cent. solution is made up each time and added to an equal quantity of old solution, the fresh solution being mixed in hot water in a separate tank fitted with steam coils. For 2,600 gallons of 6 per cent. solution the following quantities of chemicals are needed:—

273 lbs. Arsenic Pentoxide.
507 lbs. Copper Sulphate.
780 lbs. Potassium Dichromate.

The plant deals with about 300-350 charges per annum, and the annual outturn is:—

Sleepers	50,000—60,000 pieces.
Poles	3,000—3,500 pieces.
Private timber	5,000—7,000 pieces.

The labour strength is 30—40 men per day.

Treatment costs are Re. 1-4-0 per c.ft. distributed as follows:—

1. Chemicals	Re.0-10-8 per c.ft.	Re.1-4-0.
2. Handling, royalty, supervision, etc.	Re.0-9-4 per c.ft.	

Annual Revenue	Rs. 3,00,000
Annual Expenditure	,, 2,20,000 as follows:—

1. Raw Materials (Royalty, extraction and transport)	Rs. 1,25,000
2. Chemicals	,, 70,000
3. Handling (Contractors)	,, 15,000
4. Establishment (Departmental)	,, 5,000
5. Stores	,, 1,500
6. Depreciation and patent costs on 'Ascu' ...	,, 3,500
	Rs. 2,20,000

Arsenic Pentoxide requirements are about 120 cwts. per annum and is obtained from the Imperial Chemical Industries at about Rs.80 per cwt. Copper Sulphate requirements are about 240 cwts. per annum and is obtained from Mysore Chemicals, Chikbanavar, at about Rs.50 per cwt.

Potassium Dichromate requirements are about 360 cwts. per annum and is obtained from the Mysore Government Dichromate Factory at Belagole at about Rs.175 per cwt.

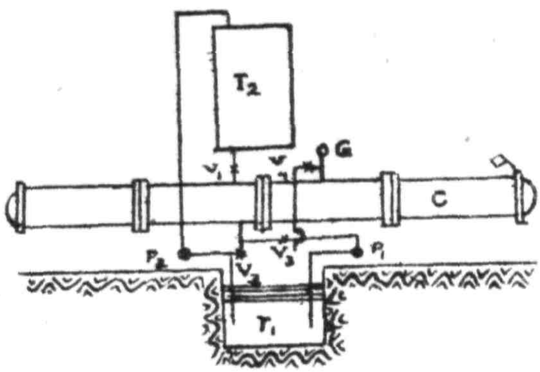
The following is a table showing data for some other timbers treated in the plant, under a pressure of 150 lbs. for about 2 hours:—

	Weight before treatment	Weight after treatment	Absorption per ft.
Canarium strictum ...	374·0	449·0	10·0
Terminalia bellerica ...	450·0	512·0	8·3
Adina cordifolia ...	381·0	486·0	14·0
Dipterocarpus turbinatus ...	511·0	575·0	8·5
Machilus macrantha ...	385·0	478·0	12·4
Pœciloneuron indicum ...	93·0	102·3	9·4

Bamboos absorb Ascu much more than wood having a comparatively large surface area per unit volume and weaker solutions of Ascu are possibly required.

Portable "Ascu" treatment plants, costing not more than Rs. 20,000 and with a capacity of 2,00,000 c.ft. per annum can be installed. Such plants consist of a 40 feet long pipe, 24 inches in diameter, in 4 sections and with arrangements for closing the mouths and making them airtight, two hand-pumps for raising the solution and for applying pressure, two tanks and the usual gauges, etc. An air-compressor with an auxiliary chamber may be used as an alternative, but more hydraulic pressure by direct pumping of solution into the treatment cylinder is adequate to secure the desired penetration.

THE CENTURY ASCU TREATING UNIT



OPERATION

Operation—

Place timber, seasoned to 28 per cent. or less moisture content, in treatment cylinder C, and close tight its mouth M. T_1 the lower tank has ASCU wood preservative in storage. With pump P_2, the wood preservative is pumped into top tank T_2, which has a float gauge to show the level of preservative in it. Valve V_2 is closed V_4 and V_1 are opened. Air in C escapes as in treatment cylinder is filled up with wood preservative by gravitation flow from T_2. When all the air has been displaced and wood preservative starts issuing from over-flow pipe. V_4 and V_1 are closed. The piston pump P_1 is started and wood preservative is pumped through V_3 till a maximum pressure of 80 to 120 lbs. per square inch is indicated in pressure gauge G. This pressure is maintained for 20 to 30 minutes. The process is completed. V_3 is closed, and V_2 and V_4 are opened. The preservative is dropped into T_1. The cylinder mouth door is opened and the timber withdrawn. It is seasoned in a roofed shed for two to four weeks, and it is then ready for use.

CELLULOSE AND RAYON INDUSTRY

Wood pulp may be said to consist of alpha-cellulose, hemi-cellulose and small quantities of lignin, mineral matter, etc.

A. Paper pulp.—The proportions of the various constituents in paper-pulp are roughly as follows:—

Alpha Cellulose	...	...	...	...	90 per cent.
Hemi-Cellulose	...	...	...	...	8 per cent.
Silicates or Ashes	...	...	...	...	1 per cent.

For rayon-pulp however the ash-content must be as low as possible and down too. 1 per cent. if possible, and the proportion of alpha-cellulose more than 90 per cent.

In Europe and America there are available white and soft woods with the requisite fibre composition suitable for producing both mechanical paper pulp and the better quality rayon-pulp but in India so far the only timbers found suitable for mechanical news-print are Fir (Abies species) which is found suitable for mechanical Himalayas, Pichola (*Kydia calycina*) which grows plentifully in the Sadiya and Lakhimpur Districts of Assam and on the north bank of the Brahmaputra generally, and Sali (*Boswellia serrata*) which grows in Hyderabad and in Madhya Pradesh, where a plant for producing news-print from a mixture of this species and bamboos has been established.

News-print plants combining chemical pulp and mechanical pulp are feasible for softwoods like fir, the mixture being 75 per cent. mechanical pulp and 25 per cent. chemical pulp, while for hard-woods, the proportion of chemical pulp admixture will be higher. The most suitable chemical pulp for this purpose would be from bamboo, which produces all the paper to-day in India.

In Upper Assam a news-print plant based on Pichola (Kydia Calycina) can be established provided 20,000 tons of this species is available annually to produce 16,000 tons of wood-pulp (on a 80 per cent. yield basis) with which 5,000 tons of chemical pulp from bamboo would have to be mixed. The minimum economic unit is one of 50 tons per diem. Even if the existing stocks of Pichola in the forests of Sadiya and Lakhimpur Districts is inadequate to support such a plant for more than 6-8 years, the necessary series of plantations of this quick growing species (300 acres per annum over a 10-year period) can be laid out.

In the Dimapur area (Manipur Road) where not less than 12,000 tons of Bhelu (*Tetrameles nudiflora*) are immediately availabe this species, which is likely to prove suitable for mechanical pulp, can be mixed with chemical bamboo pulp from the proposed paper-mill, and one combined plant for both quality paper and news-print is possible here.

B. Rayon pulp.—Rayon or artificial silk has all the texture fineness, and beauty of real silk without its expensiveness and has been described as the "poor man's luxury". Rayon yarn can be woven on both handlooms and in mills. In Travancore about 4,000 handlooms use imported Rayon yarn, while 200 mills in India have adopted some 15,000 looms for manufacture of Rayon fabric. Thus the marketing possibilities are great, and the Government of India have approved of seven factories in this country, of which three have already been set up.

In Hyderabad a factory to utilise lin[illegible]res in the Cotton Textile Industry, for acetate rayon manufacture has been started.

In Travancore a plan has been erected to utilise at first imported cellulose pulp and later to manufacture cellulose pulp from the bamboo Ochlandra travancorea. The output is 5 tons of viscose rayon and ½ ton of transparent paper per diem.

In Bombay the Government have sanctioned the erection of 2 pilot plants, one for manufacture of rayon-cellulose pulp from bamboos and the other for manufature of rayon yarn from the pulp produced by the first plant, at a cost of some 12 lakhs of rupees. This plant can produce 7 tons of rayon pulp a day.

Exepriments with the reeds Arundo Donax and Phragmites Karka for manufacture of rayon-pulp have yielded very encouraging results and Italy is using it for this purpose.

In this connection the following extract from the Progress of Forest Research in Assam for 1948-49 is of interest :—

"80. *Industrial aspect.*—Samples of *Arundo donax*, *Phragmites karka* (Nal) and *Neyraudia spp.* (Khagra) collected by this Department from Assam recently and supplied to research institutions in and outside India have produced one of the best rayon (artificial silk) in the world. This has encouraged the possibility of having a rayon industry in Assam in view of the abundant occurrence of the above species.

81. The following table shows the results of the analysis of the above-mentioned reeds :—

Raw Material	Yield of pulp per cent.	Alpha cellulose		Ash per cent on pulp	Pentosan Content	
		Per cent. on pulp	Per cent. on material		Initial	Final after NaOH treatment
1. Phragmites karka (Nal)	32·05	85·82	27·50	0·20	10·20	3·85
2. Arundo donax ...	33·87	85·24	28·87	0·16	10·03	3·26
3. Neyraudia reynaudiana (Khagra).	36·30	85·42	31·01	0·21	11·14	3·60

82. It may be confidentially said therefore that the pulp obtained from these Assam reeds is suitable for the manufacture of rayon and other allied products. The yield of pulp from Khagra (Neyraudia spp.) is slightly more than from Arundo Donax and Phragmites. In Assam Arundo Donax is not so plentiful as the other two species being confined mainly to the hills.

In a few years there will be a demand for at least 100 tons of rayon-cellulose per day for the manufacture of rayon and there are sufficient raw materials within Assam to permint of the whole quantity being manufactured in the State from local raw materials, mainly Nal, Khagra and bamboos.

The Rayon Industry is of importance both from the point of view of production of Filament Rayon and Staple Fibre, which is a substitute for cotton, now in short supply. Further research is needed to ascertain the best rayon-ply and rayon-pulp and even assuming that the rayon plants are located outside the State, there is no reason why Rayon-pulp manufactured in Assam cannot be sent to Rayon-plants wherever they are situated. Moreover it should be possible to utilise the proposed Paper-Mills to produce, if not whole at least a portion of the required quantity of rayon-cellulose by the same (Sulphate) process, which is used for paper manufacture. It is unfortunate therefore that other areas have, taken the lead, though less well situated than Assam from the point of view of raw materials.

Rayon manufacture requires very large quantities of suitable (soft) water which is an important consideration in the location of the plant Bamboos and reeds are important sources of raw materials for the rayon industry and in both

respects the Dimapur area, which is conveniently placed for abundant bamboo and reed supplies and has the Dhansiri river for water and coal and limestone in the adjoining Mikir Hills, fulfils most of the requirements for a composite Paper-Rayon Plant.

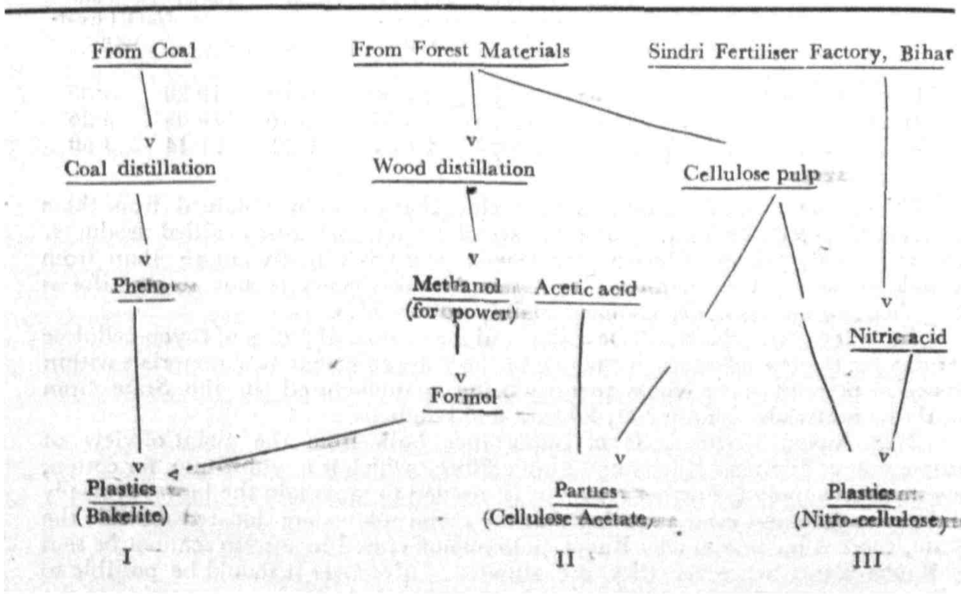
II —Plastics

Plastics may be made from wood cellulose or coal and may therefor be cellulosic or non-cellulosic in composition. Bakelite is a plastic of the latter group.

In India there is as yet no coaltar industry, by which is meant the *destructive distillation of coal to produce various by-products, including tar and gases,* so there is no immediate prospect of large scale production of non cellulose plastics like Bakelite. But it is possible to produce plastics from wood-cellulose and products of wood distillation.

The following diagram shows briefly and simply the processes involved. We can, at the moment, be interested only in the II and III types of plastics, for which Assam with its abundance of wood, bamboos and reeds is well situated. Wood distillation will give us charcoal and methanol which can be used for transport power, and acetic acid which is also in demand, while a cellulose-pulp industry can provide paper and rayon-cellulose as well as materials for plastics, raw film manufacture, etc. Nitric acid will be available from Sindri Fertiliser Factory in Bihar which is within reasonable distance.

Thus Assam can have a wood distillation industry as well as a cellulose-pulp industry, the latter to include paper and rayon pulp as well as the main raw materials for plastics from the surplus and waste forest materials available.



PAPER AND PULP

Paper is defineable as a mat of cellulose fibres which is formed in water, and which after over 90 per cent. of the latter has been removed, is treated with chemicals such as rosin, alum, starch, gelatin, etc., to form the article we know as paper.

Cellulose is a natural high polymer made up of $C_6 H_{10} O_5$ groups (Glucopyranose) repeated in chains linked to each other by bonds which are soluble in acids—a very large number of these $C_6 H_{10} O_5$ units, each not more than 1/25000th of an inch thick, are bound together in bundles of 10 to 100 to form fibres. The permanency or durability of paper which is its most important quality, depends partly on the treatment particularly the sizing, as well as on the nature of the cellulose fibres constituting it, which in turn depends on the lengths of their polymer chains. New cloth rags which provide paper of the greatest permanency, contain 3,000 polymer chains, old rags only 200-250, while sulphite chemical wood-pulp has about 1,000 chains.

In Europe and America paper is made almost entirely from wood-pulp of coniferous timber, the better quality papers from admixtures of rags and grasses England which makes some of the best quality paper in the world imports large quantities of Esparto grass from North Africa and pulp from other countries—her only raw materials are coal, limestone, other chemicals and rags. In India paper is mainly made from bamboo, but news-print is made from imported mechanically ground wood-pulp. Originally, before the introduction of cheap mill-made paper from bamboo killed it, the hand-paper making Industry had flourished for centuries in India, the main raw materials being bark of trees, grasses and rag-cloth. The modern hand-paper industry in India has been revived by Government and is making good quality paper, mainly from rags, with modern methods and machinery. It is essentially a family unit or cottage industry.

India's estimated consumption of paper at present is over 3 lakhs tons, which represents about 1 lb. of paper per person as compared to the United States of America's consumption of 350 lbs. per person per annum. Only a little over 1,00,000 tons of paper is produced in this country, and about 8 crores of rupees per annum are spent on import of this essential material.

Of all the States of India, Assam has the greatest resources of the main raw material for the manufacture of paper, *i.e.*, bamboo, yet it has no paper-mill !

It is estimated that some 3,00,000 tons, dry weight, of bamboos are readily available which can support several paper mills. Productive capacity of the main districts is approximately as follows :—

Cachar	30,000 tons (dry weight).
Garo Hills	80,000 ,,
Lakhimpur	50,000 ,,
Dhansiri Valley	40,000 ,,
Nowgong	80,000 ,,
Khasi and Jaintia Hills	30,000 ,,

During the war about 45 million bamboos were supplied both from forests and villages. There are no less than 51 species of Bamboos occurring in Assam, but from the point of view of availability and suitability the following six species are important :—

1. Bambusa tulda (Jati, Mirtenga).
2. Dendrocalamus hamiltonii (Kako, Pecha).
3. Dendrocalamus longispathes (Khang).
4. Melocanna bambusoides (Muli, Tarai).
5. Pseudostachoum polymorphum (Bajal).
6. Teinostachyum dulloo (Dalu).

All these are hollow bamboos, there being no solid bamboos in Assam, like Dendrocalamus strictus, which is the predominant species utilised for paper manufacture in India.

Raitt, the pioneer of work in India on the bamboo as a raw-material for paper, has stated that as a paper-making material Muli (*Melocanna bambusoides*) is in a class by itself, and that it is suitable for any grade of paper.

The Sulphate process, combined with fractional digestion, of manufacture of paper from bamboo has become a standard practice in India and gives the highest yields with the best colour, and at the lowest cost.

A paper-mill with a daily capacity of 50 tons of paper made entirely from bamboo will require the following raw-materials per diem, approximately :—

1. Bamboo at 2·5 tons	per ton of paper	...	125 tons daily (50,000 bamboos minimum).
2. Coal at 4·0 tons	ditto	...	200 tons daily.
3. Glaubers Salt at 0·2 tons	ditto	...	10 ,, ,,
4. Limestone at 0·2 tons	ditto	...	10 ,, ,,
5. Salt at 0·14 tons	ditto	...	7 ,, ,,
6. China Clay at 0·1 tons	ditto	...	5 ,, ,,
7. Rosin at 0·2 tons	ditto	...	1 ,, ,,
8. Alum at 0·5 tons	ditto	...	2·6 ,, ,,
9. Alkali at ·07 tons	ditto	...	3·5 ,, ,,
10. Dyes at ·0014	ditto	...	·1 ,, ,,
11. Cassein at ·004 tons	per ton of paper	...	·02 ,, ,,
12. Paperine at ·0003 tons	ditto	...	·015 ,, ,,
13. Glue at ·0001 tons	ditto	...	·005 ,, ,,
14. Acids at ·00018 tons	ditto	...	·09 ,, ,,
15. Sodium Sulphide ·0001 tons	ditto	...	·01 ,, ,,
16. Silicate Soda at ·0002 tons	ditto	...	·01 ,, ,,
17. Soda Ash at ·025 tons	ditto	...	·12 ,, ,,
18. Lubricating oils at ·04 tons	ditto	...	·2 ,, ,,
19. Imported Wood Pulp at ·1 tons	ditto	...	·5 ,, ,,
20. Rags at ·02 tons	ditto	...	·1 ,, ,,
21. Waste Paper at ·015 tons	ditto	...	7·5 ,, ,,

A water supply of about 50,00,000 gallons per diem, a labour force of about 1,000 persons, and a site of about 50 acres of land for the factory site, etc., will be required. The capital investment will be not less than 2½ crores of rupees. Electric power may be used for working the machinery but as steam is necessary for the different processes (boiling or digesting of bamboo-chips, washing of pulp, drying of paper, etc.) and as steam cannot be economically generated in electric boilers, the use of coal cannot be avoided. Proximity to a coal-field is therefore as reasonable as proximity to bamboo-forests, if the heavy transpor charges on coal and bamboo are to be avoided.

There are 3 main zones in the Assam Valley suitable for the location of paper-mills because of the availability of bamboos and coal—these are the Garo Hills area in Lower Assam, the Dimapur area in Central Assam, and the Ledo-Lekhapani area of Upper Assam. Of these the first will have to await development of the communications to coal-fields in the intererior of the Garo Hills. The Dimapur site will have to depend on bamboos from the surrounding areas and from the North Cachar Hills, and for coal from the Mikir Hills. The Hydro-Electric possibilities of the Diphu river where it emerges from the Naga Hills are also there, and in addition this area offers possibilities for the development and integration of other industries such as Sugar, Cement, Plywood, Saw-mill and Treated Timber. The Ledo-Lekhapani site has been selected by a Company for a paper-mill mainly because of its proved resources and accessibility of coal and bamboos, the latter of which is available to the tune of 50,000 tons per annum. In addition the Surma Valley is rich in bamboos which can be floated down the main streams into the Barak or Surma river and also by that river from Manipur. The original selection for Assam's paper mill was the Badarpur-Karimganj site but coal and limestone will now have to be brought from Dimapur or Uppef Assam instead of as originally proposed from Chattak, which has fallen in East Pakistan. Assam therefore offers scope for at least 4 paper mills based on bamboos, and is an attractive proposition for the capitalist who wants to be near his main raw-materials, bamboos and coal.

In addition to bamboos, Assam has enormous resources of grasses and reeds of several kinds, though Sabai grass (*Eulaliopsis binata*) the main grass used in the Indian paper industry at present, (to the extent of 22 per cent., the other chief raw material being bamboo), is not found. Apart from Sunn or thatching grass (*Imperata arundinaceae*) one of the species found most plentifully in Assam is the reed Nal (*Phragmites karka*). This species has recently been successfully tested for paper manufacture at the Forest Research Institute, Dehra Dun, but as the fibres are rather short it will be advisable to mix it with long-fibred species such as bamboo. Nal is plentifully available at Dimapur.

Newsprint.—India does not produce any newsprint at present, and has to import all its requirements, which are expected to reach the figure of 1,00,000 tons valued at Rs.7½ crores per annum. There is a world shortage of newsprint and prices are going up, while the need for more newspapers in India cannot be questioned. In view of this situation the possibility of establishing a newsprint industry in the country is actively engaging the attention of the Government of India.

Wood is the most important single raw material in the manufacture of newsprint, and coniferous wood is the main source of the necessary pulp-wood in other countries. In India Spruce (Picea morinda) and Fir (Abies pindrow), the main coniferous pulp-wood are found in the Himalayas, but the necessary surveys of the factors for establishing a mechanical pulp or newsprint industry, such as cheap power, plentiful water, cheap transport, availability of raw materials, proximity to markets, etc., have yet to be done in detail. As the capital expenditure will be in the neighbourhood of Rupees 5 crores, the necessity for a thorough examination of the position is all the more clear.

The brood-leaved species or hard-woods are generally less suitable as raw materials for newsprint as they have shorter fibres and are more difficult as to grind than conifers. The question of the dark colour of the resultant pulp-wood is also important—Eucalypt pulp used in Australia for newsprint has to be bleached. But experiments in France on various West African timbers have demonstrated that tropical forest timbers, even in heterogenous mixture, can be successfully converted into paper and that shortness of fibre is not so important as anatomical-properties (cell-wall thickness, etc.). This offers great hopes for Assam with its large number of miscellaneous species now lying unutilised.

Of the Indian timbers (apart from the Himalayan conifers Fir and Spruce) which have been tested for newsprint at the Forest Research Institute, Dehra Dun, in the past, the following gave satisfactory results :—

1. Boswellia serrata (Salai).
2. Lannea grandis (Odina wodier), Jhingan.
3. Garuga pinnata (Khatpat).
4. Eucalyptus globulus (Blue gum).
5. Excaecaris agallocha (Gangwa).
6. Kydia calycina (Pula or Pichola).
7. Butea frondosa (Dhak).

Unless anyone species occurs compactly in a locality in sufficient quantity, it will not be safe to base a newsprint industry on it even though the pulp is light in colour and possesses sufficient fibre-length and strength valve. So far in India only Fir and Spruce satisfy all these conditions, but their situation in the high Himalayas renders their ulilisation very difficult. *Lannea grandis* and *Garunga pinnata* occur all over Assam, though exact quantities are unknown.

Another species recently tested and found suitable for paper, though the bleaching costs are rather high is *Tetrameles nudiflora* (Bhelu) which is found plentifully, particularly in the middle Assam Zone. At least 10,000 tons of Bhelu are available in the Dimapur area. In Madhya Pradesh a plant based on a mixture of *Boswellia seurata* (machanical pulp) and bamboo (sulphate chemical pulp) in the proportion of 70 to 30 per cent. is under installation, so there is no reason why a similar plant based on a mixture of Bhelu and bamboo should not be installed at Dimapur in Assam. The potential annual output of bamboos from the Langting-Mupa Reserve in the North Cachar Hills, which is within easy reach of Dimapur with a direct rail connection is nearly 80,000 tons per annum, in addition large quantities of Nal reeds (*Phragmites Karka*) are available in this locality, as stated above under 'Paper'. So the possibilities of this site with its resources of cellulosic raw materials, bamboos, Bhelu and Nal, coal, limestone and water are among the most atractive in Assam.

Kydia calycina (Pichola) occurs plentifully in the Sadiya and Lakhimpur Districts, and it is calculated that about 2,000 tons of logs per annum, sufficient to yield 1,500 tons of pulp, will be available for a few years from the Reserve Forests of Sadiya and Dibrugarh, apart from the supplies from the Unclassed State Forests. A series of plantations of this quickgrowing species can be laid out within ten years at the rate of 300 acres per annum to produce 20,000 tons of timber annually which on an 80 per cent. yield basis would give 16,000 tons of pulp, to which 5,000 tons as chemical bamboo pulp could be mixed to sustain an economic unit. Even if Pichola is not suitable for newsprint, it could produce good quality magazine paper when mixed with bamboos. There is therefore a bright prospect for such an paper-unit located in the Ledo-Lekhapani area close to the coal supplies.

One species that does not yet occur in anything like commercial quantities for a newsprint industry but which has been found to be very suitable from the pulp point of view is *Broussonetia papyrifera* or 'paper mulberry'. This tree has been grown successfully in Assam and in the Dimapur-Rangapahar area its growth-rate has been found to be very rapid. Normally this species attains to adequate pulp-wood size in 10 years, and a series of plantations can easily be laid out in any of the Reserves within easy reach of Dimapur.

It will thus be seen from the above brief remarks, that the prospects of establishing industries based on cellulosic raw materials (paper, pulp, fibre-boards, rayon, etc.) are particularly bright in Assam as it has an abundance of raw materials.

WOOD DISTILLATION

BY

B. Saikia

Wood distillation in a very crude and wasteful form is practised to some extent in some parts of Assam, mainly in the Khasi and Jaintia Hills, for the manufacture of wood charcoal for use as domestic fuel. The wood distillation industry was originally built up to supply charcoal, and as such much of the bye-products of the distillation process, on the recovery of which the present-day wood distillation industry is based, was let off into the atmosphere and nothing or very little of it was recovered. But with the advent of coke for use in blast furnaces and the development of other superior quality domestic fuels, the wood distilliation industry had to look towards efficient recovery of every one of its bye-products, *e.g.*, wood-alcohol (methanol), methyl acetone, acetate of lime, tar, etc., besides, the main product, charcoal. The economy of the whole wood distillation industry depends on this efficient recovery of all its bye-products which are used extensively in the chemical and plastics industries and in metallurgical operations.

Wood distillation as an industry, for distilling both hard wood as well as soft coniferous woods, can be taken up in Assam on the following basis :—

1. Distillation of wood in small units, with retorts made of iron drums set in a well designed brick furnace, and collecting all the products of distillation.

2. Heating the retorts containing the wood with non-condensable wood gases formed during the process of distillation.

3. Collection of the condensed volatile products of distillation and re-distilling them for the recovery of their various constituents.

Hard woods, on distillation, yield the following principal products :—

1. Charcoal
2. Wood Alcohol (Methanol)
3. Acetic Acid
4. Acetone
5. Tar

(3–5: Pyroligneous Acid.)

Other minor products present in the pyroligneous acid also can be recovered depending on their demand. Yield of the condensed volatile products as well the quality of the charcoal obtained depend on the kind of wood used and the mode of firing. Although industrial production of synthetic methanol has seriously threatened the hardwood distillation industry, the search for other products by new distillation methods goes on.

Average yield per ton of dry hard wood: (*Ford Motor Co., Iron Mountain Plant, U. S. A.*)

Charcoal	600 lbs.
Methanol	25 ,,
Soluble tar	22 gallons.
Pitch	60 ,,
Creosote oil	3·25 ,,
Ethyl Acetate	14·7 ,,
Methyl Acetate	1·0 ,,
Non-Condensible gases	5,000 c. ft. (290 BTU per C. Ft.)

This gives an idea of the approximate yield of products in the process of distillation. The gas generally represents 20 per cent. of the weight of the wood used.

It is to be noted that the distillation of pine and other softwood do not give the same products: the yield of pyroligneous acid in the distillation of pine is less and a much lower percentage of acetic acid and methanol is obtained, the main products of distillation being oil of turpentine, along with various other products like the light oils, pine oils, dipentine tar-oil, etc.

CHARCOAL MANUFACTURE

BY

B. SAIKIA

I.—*Charcoal Manufacture in general.*—Charcoal is prepared by heating wood out of contact with air. It was at one time an important metallurgical fuel, but is to-day used only to a limited extent for that purpose.

(*a*) *Kilns.*—Many types of kilns are used for the manufacture of charcoal all over the world. These may be classified into three different classes:—

1. Indigenous charcoal kilns.
2. Brickwalled charcoal kilns.
3. Metal-charcoal kilns.

Almost all the charcoal made in India is manufactured by the indigenous method, that is to say in kilns which can be made in the forest with local materials. These are generally of a paraboloid type and are considered more economical. A single open pit is also used, as in the Khasi and Jaintia Hills, but it is very wasteful, though it has the advantage of producing charcoal in a very short time and requires very little skill.

Ordinary earth-kilns give dirty charcoal mixed with lumps of earth which subsequently requires careful handpicking, but in consideration of the difficulties of transportation, etc., such temporary kilns are sometimes unavoidable. Permanent kilns are only possible where the market is steady and where the outturn of fuel per acre is high and suitable communications exist to ensure a steady supply of wood from the forests at a reasonable rate.

(*b*) *Yield.*—The percentage yield of charcoal obtained from wood depends not so much on the species of wood or on the type of wood as on the method of manufacture and the skill of the burner. Dry wood produces more charcoal than wet wood of the same species, and a fair yield of charcoal from any wood may be put at between 20 to 30 per cent. of the weight of the original wood. The percentage yield of different types of kilns are:—

Open pit	15—20 per cent.
Prismatic type kilns	18—22 per cent.
Paraboloid kilns	20—25 per cent.
Brick kilns	25—28 per cent.
Metal kilns	25—33 per cent.

On an average the yield of charcoal hardly exceeds 20 per cent. of the weight of the original wood.

Systematic and organised charcoal making in permanent kilns has one great advantage in that waste gases due to decomposition and distillation of hydrocarbons may be used in heating up subsequent kilns and this distinct advantage is the essential feature of the Pierce process followed in the United States of America

The kiln is charged with wood and is then closed and heated with non-condensible gases from another kiln, the gases and the tarry matter evolved passing through condensers which recover the bye-products. The non-condensible gases are used again for heating another kiln. There is usually more gas than is required for charring and this can be profitably utilised for heating boilers, for the production of power, and for other purposes. The charcoal produced in these kilns is somewhat denser than that burnt in clump or heaps.

The best results are obtained with air-dried woods, and burning of green wood is very wasteful. Wood must be properly packed in kilns and in any one kiln large and small billets should not be mixed. For each kiln pieces of fairly even size should be sorted out and it is always better to burn only one species of wood in one kiln. Softwood and hardwoods are never to be mixed.

(c) *Properties of Charcoal.*—Properly carbonized charcoal is jetblack with a metallic lustre and with the texture of the wood visible in the charcoal. Wood burnt at a low temperature yields charcoal which has a high proportion of tarry and volatile matters and burns smokily whereas wood burnt at too high a temperature yields charcoal which is hard and difficult to ignite. There is however an optimum temperature for carbonisation and it is here where the skill and experience of the charcoal burner comes into play. It is not possible to use mechanical control aids like pyrometers, etc., in indigenous kilns and the skill can be obtained only by long practice and experience. The calorific value of charcoal should be around 1300 Btu and it must burn with a clear bluish flame with little smoke. The specific gravity of good charcoal should be 0·400 or over, but charcoal from coniferous timber is lighter. Screening is essential to ensure fairly uniform size if the charcoal is meant for special use like those in generators or motor trucks, etc. Charcoal requires good and careful storing in as dry a place as possible. The use of gunny bags, specially oily ones, is to be avoided on account of the possibility of spontaneous combustion.

The superiority of charcoal over ordinary wood is due to the intense, steady, and prolonged heat obtained from it, the ease with which it lights and the absence of any smoke when it burns. For these reasons it is being used for a variety of purposes both industrial and domestic.

II.—*Charcoal Manufacture in India.*—The manufacture of charcoal, or charcoal-burning as it is more popularly called, is an important industry and provides livelihood to forest dwellers in many parts of India.

1. *The paraboloidal over-ground kiln*—Is the best known and the most commonly used one in India. A convenient size of kiln of this type is one with a radius of 8 to 10 ft., and a height of 8 ft. It is built in the shape of a paraboloid with a capacity of roughly 800—1200 stacked cubic feet. The time taken for complete carbonization is from 7 to 10 days varying with the size of the kilns, the size of the billets, and other factors.

2. *The Oven Kilns.*—Used mainly in U.P. and Punjab with a thick covering of mud, which becomes baked into a hard crust at the first burning and is afterwards kept as a permanent kiln. They are usually similar in shape to paraboloid kilns.

3. *Pit Kilns.*—Similar in shape to the paraboloid kiln with the lower part of the kiln within a pit dug in the ground.

4. *Prismatic Kilns.*—A rectangular kiln with rounded sides, generally used in Madhya Pradesh.

5. *Hill Kilns.*—Merely an adaptation of other types of kilns to suit hilly countries where level sites are difficult to find.

6. *Portable Metal Ki ns.*—Composed of metal plates joined together to form the sides with the top being closed by a metal roof. It has the advantage of eliminating difficulties from varying weather conditions. Increased use is being made of this type of kilns in which metal plates replates the covering of leaves and earth used in other types of kilns. When dismantled the kilns can be carried over distances by carts or coolies and easily reassembled for use again.

III.—*The Lakhimpur Operation of 1943.*—Very little has been done in Assam towards manufacturing charcoal on a scientific basis even though fair quantities of charcoal are produced every year mainly for domestic use. With a view to investigating the possibilities of manufacturing producer gas charcoal for emergency purposes during the last war, a small scale Forest Department Operation was started in the Lakhimpur Division at Khowang, near the Assam Trunk Road, in 1943. A total of 34,560 cubic feet of fire-wood was burnt for charcoal manufacture yielding 1,720 mds. of graded and washed charcoal. The main species used were Uriam, Otenga and Morhal. Generally speaking the quality of charcoal obtained was fine. Uriam made good charcoal, hard and clean, but the charcoal made from the other two species, *e.g.*, Otenga and Morhal, tended to break into strips. Probably other species, like Amari, Hollong, Jamun, Nahor, Paroli and Ahoi which are moderately plentiful would be suitable. It was observed in the operation that the size and type of the kiln made no appreciable difference to the average outturn of charcoal, the yield of which was about 24 per cent. by volume, *i.e.*, one maund of charcoal required 20 cu. ft. of stacked firewood. Experimental burning was carried out in Bee-Hive mud kilns.

Including the transport charges from the forest to the kilns, the actual cost of the operations came to Rs.5-3-6 per maund of charcoal. It was estimated that of the total cost, 51 per cent. of it accounted for cost of firewood alone, while cost of labour amounted to another 30 per cent. However it was estimated that if the operation was carried out in the forest a saving of Re.1-12-0 would have been affected on the cost of transportation of firewood alone and on large scale production the cost at kiln side in the forest would be about Rs.4 per maund.

The whole operation of building a kiln, firing, burning, cooking, unloading and grading and bagging took 16 days. It was suggested that a continuous operation with a batch of 16 kilns of 12 stack capacity each (1,300 cu. ft.) should be resorted to. This would necessitate 60 labourers and one Forest Guard for each centre of manufacture with one subordinate to supervise.

IV. *Conclusion.*—Regarding the type of kiln for use for any possible charcoal burning industry in Assam, the then Senior Conservator of Forests, Assam, during the Lakhimpur Operation days (1943) suggested a kiln of a paraboloid type 8 ft. in height with a radius of 10 ft. at a ground level with 1,200 stack cu. ft. capacity yielding about 30 tons of charcoal. The description and instructions given for its construction were based on Troup's Indian Forest Utilisation (1907 *ed*). But considerations of later developments made in various types of kilns and the technique of charcoal burning is necessary, particularly of the following types of kilns whose possibilities of working in Assam should be investigated.

1. The Siamese Kiln.
2. The Portable Metal Kiln.

Detailed description of the Siamese type of kiln is given in the Indian Forest Bulletin No.54 published by the Forest Research Institute, Dehra Dun. This type of kiln, introduced by the immigrants from Thailand into Malaya, has been mainly responsible for the growth of an important charcoal burning industry in

Malaya since 1930. The kiln claims the following characteristics and advantages:—

1. Basically made with local materials and house builders bricks.
2. Charcoal produced is of good quality and the percentage of impurities and imperfectly burnt charcoal is low.
3. The yield of charcoal is approximately 27 per cent. with 3·7 parts of wood giving one part of charcoal.
4. It can be erected anywhere.

Also *see* Malayan Forester, April 1950, pp.80-33.

The Portable Metal Kiln is also used extensively and the one specially designed by the Forest Research Institute, Dehra Dun, made of mild steel, claims various advantages over other types of similar kilns.

Whatever the type of kiln used, it should be always borne in mind that all the bye-products of charcoal burning have to be recovered and utilised, thus eliminating the current wasteful methods of burning charcoal. Since charcoal to-day has very limited use, its place as a metallurgical fuel having been taken over by coke, if an industry on charcoal burning has to be planned we have to take into account all the aspects of recovery of the bye-products, on which alone the success of the industry depends.

THE LAC INDUSTRY IN ASSAM

BY

B. SAIKIA

1. *General.*—Lac, a complex resinous secretion of a small buglike insect called Laccifer lacca, thriving on the sap of certain trees known as hosts, is grown in many parts of Assam. The most important areas growing lac in Assam are the Mikir Hills and the Garo Hills. From the revenue point of view it is one of the most important minor forest products. The production of lac in Assam is not steady as will be seen from the following production figures over the last ten years. The production of stick-lac in Assam came down from a peak figure of 36,000 maunds in the year 1942-43 to a minimum of only about 2,000 maunds in the year 1945-46, but appears to be again on the increase.

Year	Mikir Hills	Garo Hills	Total for Assam	Total for India
1940-41	8,500	1,500	12,000	12,33,400
1941-42	19,000	6,500	31,000	14,65,000
1942-43	21,000	9,000	36,000	13,73,800
1943-44	11,000	7,000	20,000	8,49,000
1944-45	4,000	1,000	5,000	9,61,800
1945-46	1,500	500	2,000	11,26,800
1946-47	6,000	2,000	9,500	17,67,300
1947-48	10,000	3,500	15,000	9,71,800
1948-49	16,000	2,500	19,500	...
1949-50	11,000	3,000	15,000	...

(All figures are rounded to the nearest hundred.)

This shows a yearly average of 16,000 mds. of lac in Assam as against 12,00,000 maunds in the whole of India.

Most of the lac in Assam is cultivated by the Hill people.

The lac is sold to middle-men who finance the trade both through cash and kind by the supply of rice and other commodities required by the Hill people from day to day. The present system is that the lac is purchased by petty dealers who resell it to larger middle men with registered godown, who in turn export the lac from Assam to Calcutta to another set of dealers, thus involving several changes of hands from the cultivator to the refiners before the lac emerges in a form suitable for industry. The cultivators are left at the mercy of the middle-men so far as the price for raw lac is concerned, though the prices offered depends generally on the official price of shellac in Calcutta. If the series of middle-men could be eliminated and the cultivators given a higher price for their product, there will naturally be a greater production of lac, though this also depends on the weather and natural causes to a large extent. Lac cultivation in a more systematic organised way through co-operatives formed by the farmers themselves, or purchase of the lac by a central agency at steady prices, would go a long way towards stabilising production in the State, while ensuring greater benefits to the hill-man cultivator. This fact was recognised by the Forest Department about 20 years ago and a proposal was made for a Government purchasing agency, but nothing came of it.

2. *Areas of Cultivation*.—The two most important lac growing areas in Assam, as said before, are the Mikir Hills and the Garo Hills. Other lac growing districts are the Khasi and Jaintia Hills, Goalpara and Kamrup with smaller outputs in Darrang and North Cachar Hills.

3. *Lac Hosts*.—Lac hosts can be found in various parts of Assam and can be grown along with other crops. Most of the lac grown in Assam is cultivated on Arhar (*Cajanus indicus*) in the Jhum cultivation of the hill tribes and to a lesser extent on *Lea Crispa* and Flemingia Congesta. All of these are shrubs. Some of the lac hosts like the Khair tree (*Acacia Catechu*) are found in the forest of the Goalpara district, while others occur scattered, mainly outside the reserves. Lac hosts found scattered in Assam are :—

1. Kusum (Schleichera trijuga).
2. Ber, Bagori (Zizyphus jujuba).
3. Palas (Butea frondosa).
4. Ghont (Zizyphus xylopyra).
5. Grewia multiflora.
6. Leea Robusta.

A number of Ficus species like Ficus altissima and religiosa can also be used as lac hosts. Lac grown on Kusum trees is of superior quality. The tree is however not gregarious and is mainly confined to cultivated areas. The season for infestation in Assam is April—May and this crop matures in September—October when reinfection is done. The periods of different lac crops is however controlled by climatic and other local conditions.

4. *Refining of Lac into Shellac*.—Raw lac is converted into shellac, the refined product, either by the old country method or by the mechanical method using the latest technical developments. In India, as far as is known, except by Angello Bros. in Calcutta, all the lac is refined by the improved country method, which accounts for over 75 per cent. of the total production of shellac in the world of which India holds a monopoly. The process of refining lac into shellac is very simple and with the help of a few hired artisans from Bihar or United Provinces this art of making shellac could be easily introduced into Assam, while

an improved lac-processing unit, based on the country method, could be set up in the State. The steps followed in the process of refining lac into shellac consists of:—

(1) Crushing of the lac in an adjustable crusher (Roller corn crusher) for separating the lac from the sticks. Sometimes the lac, as in the Baisakhi crop, is scraped off from the sticks and the sticks removed by handpicking.

(2) Washing the crushed lac in cemented vats to separate the crimson coloured dye, when seed lac is obtained.

(3) Conversion of seed lac into shellac by melting in long cloth-bags over charcoal fires when the purified molten lac is squeezed out.

(4) Making of the shellac sheets by placing the molten lac over glazed procelain surfaces and stretching the sheets by hand. It is in this process that the most skilled craftsmanship is required. In the country process the purification is carried out by using the least amount of heat on which so much of the good quality and colour of the shellac depends.

About 25 per cent. of the shellac in India is processed by the mechnical method using steam and solvents.

Based on the country process an improved lac refining unit could be established in Assam to handle a portion of the lac produced in the State. Thus a small lac refining unit processing about 10 maunds of lac a day could be easily established to start with in the Mikir Hills area, together with systematic publicity and improved methods of cultivation, bringing greater revenue to the State and raising the standard of living of the people.

5. *Conclusion.*—For ensuring expansion of lac cultivation in Assam and retention of the resultant benefits within the State the following points require special emphasis:—

(1) Cultivation of lac by the growers in a more systematic and organised way through co-operative societies formed by the growers themselves and under improved methods.

(2) Disposal of the products of cultivation through a central agency, eleminating most of the middlemen in the trade.

(3) Starting lac-refining units in Assam on a modest scale to begin with.

(4) Systemetic grading of lac and the control of quality of both lac and shellac to ensure a steady price and demand.

(5) Giving proper publicity for lac as a cash-crop and education of the growers in lac economics.

ROSIN AND TURPENTINE INDUSTRY IN ASSAM

BY

B. SAIKIA

Introduction—

Besides timber and fuel the pine tree yields two most important products, *e.g.*, rosin and turpentine. Rosin is a solid golden yellow brittle substance and oil of turpentine is a colourless, mobile liquid. These two products are used in various industries like soap, textiles, paper making, paints and varnishes, chemicals, medicine etc.

Turpentine and Rosin are obtained from the pine trees by two distinct methods:—

(*a*) By destructive distillation of the resinous wood from pine trees when products like turpentine, light oils, dipentine, pine oil, tar-oil and pine-tars are obtained, charcoal being left as a residue. In this case the rosin is broken up into tar, etc.

(*b*) By extracting the oleoresin from the resinous trees by tapping, *i. e.*, by making incisions on the pine trees and collecting the exuded resin in proper receptacles. The term oleoresin is used to indicate the viscid substance which exudes from the trees when incisions are made on the stem of the tree. On steam distillation the oleoresin breaks up into rosin and oil of turpentine. This is the process followed in India for manufacture of rosin and turpentine.

India uses huge quantities of both rosin and turpentine. Some of these are imported from foreign countries like U. S. A. France etc., and part of the national consumption is met from products manufactured in resin distillation factories mainly located in Uttar Pradesh. There are resin distillation factories also in Pakistan and Kashmir. Of the various species of pine trees indigenous to the sub-continent, extending from the North Western Zone to Assam in the North East, there is only one species, *e. g.*, *Pinus longifolia*, that is being exploited on a commercial scale. The other good resin yielding species like *Pinus merkusii* and *Pinus khasya* are not yet being exploited on any commercial scale, even though these two species of pines yield the best quality resin.

Pinus khasya is found in Assam in the Khasi and Jaintia Hills, wherefrom it derives its name as well in the Abor and Mishmi Hills, Naga Hills, Lushai Hills, Manipur Hills and in the Balipara Frontier Tracts.

History of Resin tapping in Assam—

Even though, as said before, *Pinus khasya* occurs in the hills of Assam, very little attempt was made in the past to exploit these pine forests in Assam for manufacture of rosin and turpentine. The history of resin-tapping in India dates back to the latter part of the nineteenth century, the first operation being carried out in the Uttar Pradesh followed by subsequent distillation. In Assam some small experiments in resin tapping were carried out as early as 1906-07 but the results obtained were considered to be unsatisfactory and the matter was left at that and no further attempts were made to exploit the pine trees.

In 1950, a Special Officer was entrusted by the Forest Department of the State to further carry out investigations into the possibilities of exploiting Assam pines on a commercial scale. Experiments in resin tapping were carried out by this officer in the neighbourhood of Shillong to find out the optimum conditions for resin tapping in these hills. About 400 trees of different diameter groups in

the Reserve Forests in and around Shillong were kept under tapping and the overall yield figures are given below :—

Resin yield : (Experimental period, 1950-1951)
Number of trees under tapping, 400.

Month	Maximum yield 3-4 days freshening interval per 100 channels.	Resin yield per 100 channels (Average) (3-7 days Freshening interval)	Temperature °F Max.	Temperature °F Min.	Rainfall (inches)
1	2	3	4		5
	lbs.	lbs.	°F	°F	Inches
1950—					
September	38·4	38·4	75·6	62·3	6·18
October	36·3	27·6	70·9	57·2	6·07
November	38·4	33·2	65·6	46·3	4·43
December	38·9	31·2	60·7	40·5	0·01
1951—					
January	35·4	35·4	58·5	37·9	0·28
February	59·8	50·0	65·1	43·3	0·0
March	68·7	58·8	72·0	53·0	1·30
April	83·1	58·8	73·6	58·0	2·34
May	39·8	38·0	73·5	57·0	6·70
June	35·0	35·0	73·7	63·6	32·22
July	40·0	35·0	73·0	63·8	37·64
August	50·0	45·0	74·0	63·6	17·34
Total for one year from September 1950 to August 1951.	(563·8 lbs. September—August).	(486·4 lbs. September-August).	..	..	114·51 September—August.

Freshenings were carried out at different intervals and the yield of resin shown above is a total for all freshening intervals from three to seven days and the maximum yield with 3-4 days freshening interval. It was observed that a freshening interval of 4 to 5 days gives the optimum yield. From the yield obtained during the experimental period it was found that an average tree of a diameter of 12 to 18 inches with one channel each gave around 5 lbs. resin during the period.

The months from May to August, inclusive, are covered by the heavier monsoon period, and no commercial tapping could be undertaken during this period. This is exactly the reverse of the resin tapping season in U. P. and Punjab where the best season for successful resin tapping is from March to November. The cold months in U. P. and Punjab are the off months for resin tapping, whereas to counteract the heavy rains prevailing in the Khasi and Jaintia Hills from May to August the cold months have to be utilised for resin tapping, even though the yield of resin is fairly low in these months.

The distribution of rainfall in inches for the five-year period from 1947 to 1951 is shown below—

	1947	1948	1949	1950	1951
January	0·14	0·0	0·97	0·26	0·28
February	0·0	1·66	1·94	2·07	0·00
March	6·22	2·21	0·52	3·07	1·30
April	6·33	11·62	12·06	2·17	2·34
May	22·13	14·89	14·37	16·32	6·70
June	16·89	26·12	16·50	32·94	32·22
July	25·34	19·51	11·53	10·66	37·64
August	14·62	15·10	13·24	20·78	17·34
September	16·18	13·86	15·90	6·18	7·45
October	12·60	12·56	4·25	6·07	12·30
November	0·03	3·80	0·46	4·43	3·32
December	0·32	0·0	0·38	0·01	0·22
Total	120·80	121·33	92·12	104·96	121·11

The resin obtained from the Khasi Pine was then analysed by the Special Officer and found to be of a every good quality, containing an average of 25 per cent. of oil of turpentine with a boiling range of 154-158 °C and clear golden yellow rosin (65-70 per cent. approx.). The turpentine oil was found to be within specifications laid down for high grade oils as imported from U. S. A. and contained about 80 per cent. *alpha-pinene*, the starting material for synthesis of camphor. The results were further confirmed by the Forest Research Institute, Dehra Dun, whose analysis is given below :—

Report on analysis of resin from *Pinus khasya* by the Forest Research Institute, Dehra Dun :—

	Sample No. I	Sample No. II
1. Physical properties	White resinous mass with a slight creamish yellow colour not very dirty, viscous, sticky with fine piney odour.	Same. But the sample contained larger quantities of suspended impurities.
2. Quantity of Resin received	1520 gms.	3150 gms.
3. Method of distillation	Steam distilled.	
4. Yield of oil	20 per cent. approx.	19 per cent. approx.
5. Yield of rosin	67·5 " "	70 " "
6. Yield of suspended impurities	0·8 " "	1·5 " "
7. Yield of moisture (by diff.)	11·7 " "	9·5 " "
8. Physical properties of the oil	Colourless mobile liquid with a fine piney smell, free from tackiness.	
9. d 30°C (Specific gr.)	0·8713	0·8648
10. n D 30°C (Refractive index)	1·4645	1·4632
11. l D 30°C (100 mm. tube optical rotation)	-4·12°	-3·82°
12 Physical properties of the Rosin	Crystal-clear, golden-coloured, light-smelling, solid mass, free from the gumming action characteristic of common rosin,	

The turpentine oil obtained from both the samples of resin was further fractionated and the fractions distilling over 155-156·5C were collected and examined as follows :—

Sample No.	Yield between 155-156·5 C	d 30°C sp. gr.	n D 30°C Ref Ind.	1 D 30°C (100 mm. tube optical rotation)
I	77 per cent.	0·8604	1·4625	—6·8°
II	71 per cent.	0·8601	1·4623	—6·02°

The two fractions distilling between 155-156·5 °C were individually examined for their respective hydrochloride derivatives. Almost the whole of the liquid fractions were converted into the solid crystallising hydrochloride derivative which on recrystallisation showed a M. Pt. of 131 °C tallying with that of the corresponding derivative from *alpha-pinene* (M. Pt. 132 °C).

Comparing the above data, it can safely be concluded that the two oils obtained from P. Khasya contain *alpha pinene* to the extent of 77 per cent. and 71 per cent. respectively and the oils will prove economical source for the production of important synthetics like camphor and terpineol, etc."

The Resin Distillation Unit for Assam –

Based on the results of experiment as to the yield of resin and its qualities, and estimation of the potentialities of the raw material resources of the Khasi and Jaintia Hills District, a scheme for distilling 2,000 lbs. resin a day in Shillong was submitted to the State Government. The scheme found approval of the Government and has been in operation from 1st April 1951. The raw material will mainly be supplied by over 100,000 trees of diameter of 12 inches and above from the Government Reserve Forest in Shillong and will, it is expected, be further supplemented by resin from private forests. It may be mentioned here that the Government Reserve Forests occupy only a little over 3,000 acres in or around Shillong, and compared to the extensive private pine forests in the District form but a fraction of the whole pine resources of the Khasi and Jaintia Hills.

The unit with a capacity of 2,000 lbs. resin a day which will work more or less as a pilot plant in exploring the pine resources of the whole of Assam will consist essentially of the following :—

1. One 10 NHP vertical boiler.
2. One melter.
3. One Mixing tank.
4. One jacketted receiver.
5. Two distillation stills (made of stainless steel).
6. One water separator.
7. One stainless steel storage tank of 1,000 gall. capacity for storage of the turpentine oil
8. Other accessories.

The special quality of the oil of turpentine with possibilities of using it for the synthesis of camphor and other products have warranted that some parts of the unit, like the distillation stills and the storage tank for the oil, be made of

stainless steel. The whole unit was fabricated in Calcutta at the instance of the Special Officer, Forest Industries, Assam, who is in-charge of the scheme. It is expected that the unit will go into production in 1952.

The cost of the scheme in the first year is distributed as follows :—

		Rs.
1. Plants and machinery	... ...	51,000
2. Buildings ...	... ...	17,000
3. Field work ...	... ...	35,000
4. Establishment	... ...	9,500
	Total ...	1,12,500

Provision is being made for a small laboratory to carry out both routine work in relation to the resin distillation unit, as well to carry out other investigations regarding utilisation of various forest products like agarwood, cinchona, pyrethrum, etc. It is envisaged that this laboratory will develop by stages until it is equipped to handle independently all minor problems of the State regarding forest products.

Economics of the Unit.—(Calculated on a daily production basis, distilling 2,000 lbs. resin a day, working 300 days a year).

Capacity of the Unit ... ... 2,000 lbs. resin a day.

Expected production ... ... 12,000 gall. oil of turpentine a year and 5,000 mds. of rosin a year.

	Rs.
A. Expenditure—	
1. Cost of resin at Rs.12 per maund (for 25 maunds)	300
2. Processing cost Rs.2 per maund (for 25 maunds) ...	50
3. Depreciation, interest, income-tax, etc., at 25 per cent. on capital investment of Rs.50,000.	40
Total ...	390
B. Income—	
1. From oil of turpentine at Rs.4 per gallon at 20 per cent. yield (40 gallons).	160
2. From Rosin at Rs.25 per maund at 75 per cent. yield (1,500 lbs.)	475
	635
C. Total Income *minus* expenditure Rs.635—390...	245
D. Net profiit (allowing 10 per cent. towards Reserve Fund and 10 per cent. for Sales and Advertisement cost).	196

Thus there is approximately Rs.200 a day as net profit from the scheme, amounting to Rs.200×300=Rs.60,000 per annum.

It is expected that this profit per annum could be pushed high up if more resin is available from pine trees from Municipal, Military and Private Forests. The distillation stills and the layout of the plant have been designed for taking up increased production.

Estimated cost of collection of resin in the first year—

Unit 1,000 trees: Yield 4,000 lbs. resin (50 mds. approx.) at 4·0 lbs. resin per channel, with one channel per tree :—

	Rs.	a.	p.
1. Labour charge: One labourer for each 1,000 trees working 8 months a year from 1st September to 1st May at Re.1-8-0 a day.	360	0	0
2. Bamboo cups or chungas at one anna each ...	62	0	0
3. Lips at six pies each	31	0	0
4. Nails numbers 1,000	10	0	0
5. Coal tar 5 seers for marking, etc.	2	0	0
6. Supervision cost at Rs.10,000 for 100,000 trees	100	0	0
	565	0	0
7. Other expenses, incidentals, etc.	35	0	0
Total ...	600	0	0

Thus it is seen that the cost of collection of resin in the first year will come to Rs.12-0-0 per maund.

The cost of collection of resin in the Nainital Division in Uttar Pradesh is Rs.10-11-7 per maund from Government Reserve Forests and Rs.11-11-4 per maund from private owned forests. (1949-50).

It is expected that the cost of collection of resin in subsequent years will be a little lower than in the first year, for the reason that most of the cups, lips and other accessories required for tapping will be used again with some replacements.

Conclusion—

Assam's requirements for rosin and turpentine has not yet been worked out, but with growing industries like soap, paper, paints and varnishes, etc., it should not be difficult to consume whatever quantity of rosin and turpentine is produced from this small plant. Also the very high quality of the oil of turpentine from *Pinus khasya* will by itself cause great demand for it. It is expected that the oil of turpentine could be used solely for the manufacture of synthetic camphor to replace part of the imported camphor which is imported every year to the tune of over 20 lakhs pounds.

The Industry when fully developed will not only increase the revenue of the State but also will open new fields for starting industries like Paints and Varnishes, which is not known now in Assam.

One significant deviation from the customary tapping methods introduced here is the replacement of the clay cups as receptacles for resin by bamboo 'Chungas' or cups, made by cutting bamboo pieces into two cups at the inter-node. Everywhere in Assam bamboos are available in close proximity to the pine forests and the bamboo cups could be used as receptacles for collecting resin. In Shillong the bamboo cups are being obtained from the Nongpoh Range about 30 miles from Shillong and being unbreakable they serve better than clay pots. In the present year with 1,00,000 pine trees to be brought under regular tapping, there will be required about 1,50,000 bamboo cups and production of these cups is being taken up by villagers as their spare time job. The introduction of resin tapping in the Khasi and Jaintia Hills have already found employment to some of the hill dwellers in the form of collection of resin from the trees and setting up the crop for production of resin.

With the working of this pilot plant in Shillong it is expected that the pine nesources of other parts of Assam and Manipur will be exploited.

CINCHONA AND QUININE

Cinchona is a small tree which grow to a height of about 30 feet belong to the order Rubiaceæ. It has opposite dark green glossy leaves, some of which turn red in the winter before falling and white or purplish small flowers growing in terminal panicles. The seeds are small and numerous, one ounce containing as much as 30,000 seeds. The plant is an exotic and a native of South America and its bark is sometimes known as Peruvian bark. Its valuable curative effect in malaria was first known in 1638 when the Countess of Cinchon, wife of the Spanish Viceroy of Peru, was cured of Malaria by a decoction of the bark since whence it has been called Cinchona. The word quinine is derived from the Peruvian word Quina-quina, meaning bark.

Cultivation of Cinchona was first attempted in India in 1859 and at present there are large scale plantations in the Nilgiris of South India and in Mungpoh in West Bengal. In Assam the history of attempts at growing cinchona go back to 1867 when experimental plantations were opened at Nongkhlaw and Jirang in the Khasi and Jaintia Hills District at various elevations under the control of the Mungpoh cinchona plantations. Cinchona succirubra gave promise of growing well in the hills of Assam but as the Bengal plantations were more promising it was decided not to extend the cultivations in the Khasi Hills. In 1884-85 the plantations which continued to be maintained by the Forest Department were approaching their natural term of existence being then 18 years old and the conclusion was that Cinchona succirubra could grow fairly well in the Khasi Hills at elevations from 800 to 4,500 ft. Experiments at Kulsi in the plains of Kamrup and at Tura in the Garo Hills in 1884-85 proved a failure. In 1911 it was decided to extend cinchona cultivation in India and various enquiries were made but it was not until 1927 that an area in the Mikir Hills was selected and planting of *Cinchona succirubra* and *Cinchona ledgeriana* was started in 1929. The experiments were continued until 1937 and were then discontinued as they had served their purpose. In 1933 a small scale plantation was successfully raised at Tura in the Garo Hills.

The production of cinchona alkaloids in India is utterly inadequate in comparison to the yearly demand of these antimalarial alkaloids and in the average the annual requirements of the country has been computed by various authorities at 15,00,000 lbs. to 5,00,000 lbs. Various antimalarial synthetic chemical products have, in the meantime, been introduced in medicine to combat malaria but none of these have yet been proved to be superior to the natural alkaloids contained in the cinchona bark. The requirement of Assam have been computed at 10,000 lbs. quinine salts a year. With a view to make the State self-sufficient in regard to quinine a scheme for the cultivation of cinchona has been taken up since 1942. According to this scheme an area covering 1,000 acres equivalent to 10,000 lbs. quinine sulphate a year has to be brought under cinchona cultivation. Since then the plantations have been extended until to-day and the total acreage under cinchona plantations, mainly *Cinchona ledgeriana*, is about 700 acres. The target of 1,000 acres of cinchona plantations, equivalent of 10,000 lbs. quinine sulphate a year, would have been reached in 1952 if extension had not been held up for 3 years to allow of vacancies being filled up. The rotation to be adopted is 7 years, which means that after 7 years growth the trees will be cut down and the resultant coppice shoots allowed to grow for another 7 years when the whole tree will be uprooted and the area replanted. This will give an annual acreage of 140 acres of

mature (7 years old) crop for collection of cinchona bark, the outturn being calculated as follows:

Yield of bark per tree ..	...	...	...	2·0 lbs.
Number of trees per acre	...	...	...	2,000
Acreage under harvest ...	...	...	...	140 acres.

Yield of bark per year is $140 \times 2000 \times 2 = 5,60,000$ lbs. It is expected that this quantity of bark per year will yield on processing approximately 10,000 lbs. of Quinine Sulphate and 5,000 lbs. Cinchona febrifuge. Cinchona febrifuge is the residual alkaloid after recovery of quinine which is also useful in the treatment of malaria.

Cinchona is rather exacting in its requirements of elevation, soil, temperature and rainfall, the ideal condition being an equable temperature of about 60°—80°F, an annual rainfall of 80-160 inches, a rich deep loamy soil and moderate slope which are not subject to frost. The best results are obtained in virgin soil and north facing slope. These conditions are to be found in the Khasi and other hills of Assam, between 1,500 feet and 3,500 feet elevations but is difficult to get much forested land as the percentage of Reserved Forests in the hills is very small and most of the soils have been deteriorated as the result of continuous jhumming (shifting cultivation). The cultivation of cinchona requires expert care. Seed is collected from November to January and the seed being very small this is an exacting task. The seed is thoroughly dried and kept in air tight containers and is sown in carefully prepared nursery beds in March-April. Germination starts in 14 to 21 days. When the seedlings develop two pairs of leaves they are pricked out into other similarly prepared beds at 4 to 5 feet spacing. The seedlings are transplanted to the planting area in June-July in previously prepared holes at 4' intervals and weeded regularly during the rains. Casualties require to be replaced. Cinchona objects to bare slopes and southernly aspects and shade trees are essential while other refinements like basket planting, application of manure etc., are helpful.

Cinchona in Madras :—

In the Nilgiris cinchona has been cultivated for nearly 100 years at elevations from 6,000 feet 7,000 feet and under a rainfall of 20" inches. There are at present almost 10,000 acres under cinchona and 40,000 lbs. of quinine sulphate and cinchona febrifuge are manufactured annually. The rotation is 15 years, the trees being grown at a spacing of $4' \times 4'$. The yield is some 3,000 lbs. of bark per acre (150 lbs. of quinine per acre). The future plan is to coppice the plants in the 7th year, as is being done in the Mungpoh plantations in West Bengal, and again at the end of the 14th year and finally uproot the plants at the end of the 21st year by which means it is hoped to double the output.

Cultivation methods and technique vary considerably from that now being followed in Assam and in two main respects appear to be quite the reverse of Bengal and Assam, *i. e.*, the plants are grown as tall straight poles as against Bengal and Assam where a bushy habit is encouraged and secondly a very heavy shade is maintained over the cinchona as against a light shade in Bengal and at the present moment no shade in Assam. The reason given for the former is the greater production of thick bark which comes off in large linear pieces as against the smaller, thin bark obtained from bushy plants while the summer temperature experienced at these high altitudes in the tropical zone demand heavy shade, specially in the hot weather.

The emphasis on all planting work is on maximum production of alkaloid content in the plant and hence more and more attention is being paid to vegetative reproduction methods such as cuttings, buddings, graftings, etc. as high yielding stocks can be used with certainty of results. Nursery

technique is very intersting, the soil for the nursery beds (or seed beds) is specially prepared by mixing forest top-soil containing a high proportion of humus, with sand to a correct consistency, ensuring high germination percentage and vigorous growth. After about 4 months the plants are pricked out into open nursery beds and spaced a few inches apart; the only shade provided is dry baraken fern fronds which are stuck upright into the soil between the plants. Rigid elimination of weeds etc. is insisted upon. Transplanting into the field into specially prepared pits is done with 8 months old plants, 8″-10″ high, from the beginning of the rains in June until planting conditions become unfavourable. The plants left over are put next year as root and shoot cuttings. Planting technique is most intensive and directed entirely to eliminate casualties. Pits are specially prepared beforehand and the soil allowed to weather. Stakes are thrust into the ground at an angle to support the plants and to prevent root disturbance by wind and the plant is tied to the stakes firmly but in such a manner so as to allow the stem to develop freely. In addition cylindrical baskets of bamboo are placed around the plant for shade and a certain percentage of planting is done in baskets. This latter is an expensive method but gives the best results.

Silver oak (*Grevallia Robusta*) is the main shade used and it is closely grown so as to provide a heavy shade. This heavy shade has another use as fuel for the boilers of the factory and for the labour force. In Assam we have not realised the importance of shade which under our conditions of comparatively low elevation is absolutely necessary.

Three to four weedings are done per annum, the operation consisting of a forking up or uprooting of all weeds over the whole area. The weeded material is placed along the contours to form ridges against soil-wash.

Costs per acre upto the end of the first year are approximately Rs.900 (with a labour rate of Re1.) rising to Rs.3,000 in the 12th years.

Cinchona in Bengal :—

In Mungpoh, West Bengal, the plantations, which are 4 in number are situated at a generally higher elevation than in Assam plantations, are each of about 2,000 acres in extent, the oldest dating back to 1860 or so. The cultivation technique there having reached a very high standard as the result of long experience, the main difference with Assam being in the employment of contour trenches and in the use of shade trees. The trenches are 20-25 feet apart on steep slopes to hold up water runoff and soil wash and are 1′ wide and 6-8 inches deep and are sown with leguminous crop such *Crotalaria* or Boga Medola on the ridges thrown up on the down hill side. The shade trees are scattered throughout the areas depending on the site and aspect. Warm southern aspects are given more shade, with *Alnus nepalensis* being the main species used for shade. Fallow areas, after cinchona has been once coppiced in the 8th year and uprooted in the 16th year, are hoed up and sown thickly with the same leguminous crop and allowed to remain like that for 4 years to recover fertility.

The factory turns about 70,000 lbs, of quinine sulphate per annum.

Extraction of Quinine from Cinchona :—

Cinchona bark contains as many as 30 different bases or alkaloids, the most important of them from the point of view of treatment of malaria being :—

Quinine	$C_{20} H_{24} O_2 N_2$
Cinchonine	$C_{19} H_{22} O N_2$
Quinidine	$C_{20} H_{24} O_2 N_2$
Cinchonidine	$C_{19} H_{22} O N_2$

These alkaloids exist in the bark chiefly as quinates and cinchotannates of Quinic acid ($C_7 H_{12} O_6$) and Cinchotannic acid ($C_{14} H_{16} O_9$).

The analysis of *C. ledgeriana* from plants grown in the Khasi Hills, Assam has given originally rather disappointing results but later analysis of bark from older plants have shown better results. The following is an analysis of Nongpoh bark (young and decaying trees, mainly from thinnings).

	Per cent.
Quinine alkaloid	2·40
Cinchonidine alkaloid	0·35
Other alkaloids	1·00
Total alkaloids	3·75
Quinine Sulphate	3·25

Another series of analysis averages as follows:

Quinine and Cinchonidine	3·14 per cent.
Total alkaloids	5·14 per cent.
Ratio of Quinine and Cinchonidine to total alkaloids ...	1:1·63.

The quinine contents are comparatively lower to those prevailing in the cinchona grown in West Bengal (about 4-5 per cent.) and Java (about 8 per cent). The low alkaloid content from the Nongpoh plantations may be due to the fact that the bark was collected from immature and dacaying trees. The alkaloid content of the roots are higher than those of the barks.

The methods followed for manufacture of quinine from the cinchona bark are based on the extraction of the alkaloids by means of acids and oils, both mineral and vegetable origin.

1. *The Oil Extraction Method.*—The time honoured and the standard method of extraction of quinine alkaloids from the bark is the *Oil Extraction* method which may be shown diagrametically as follows:—

Powdered Cinchona bark
|
Lime and water
|
Caustic Soda and water
|
Mineral Oil (hot extraction) (repeated several times).
|
Clear Oil Extract (Filtration)
|
Dilute Sulphuric acid
|
Clear Alkaloid acid (filtered and heated)
|
Caustic Soda (neutralised)
|
Centrifugal Filter

Crude Quinine Sulphate	Liquor
Decolourised with activated carbon	Excess Caustic Soda
White Quinine Sulphate	Cinchona Febrifuge.

This is the method followed in the Nilgiris and the West Bengal factories in India. The high boiling mineral oil used is generally paraffin oil. Benzene is also used in places.

2. *Acid Extraction Method.*—Extraction of alkaloids with acids (hydrochloric acid) followed by precipitation with alkalies is generally considered to be uneconomical and cumbersome. However, with low alkaloid content barks like those of *C. ledgeriana* from the Nongpoh plantations, the extraction of the bark with dilute hydrochloric acid at room temperatures is found to be suitable. The extraction of the colloidal matters from the bark is favoured at low acid concentrations and at higher acid concentrations colouring principles from the bark is extracted. With sulphuric acid the percentage of alkaloids extracted comes to a lower figure.

3. *Extraction with Oil of Turpentine.*—Turpentine oil being a good solvent for Cinchona alkaloids and also because it does not extract so much of inert materials as in the acid extraction method has been tried in the laboratory as another solvent for extraction of quinine from cinchona bark. With C. ledgeriana bark turpentine has proved to be a better solvent than either high boiling solvents like paraffin or benzene, and the alkaloid principles can be extracted at room temperatures with simple percolation of the oil through the powdered bark.

Experiments in this line with Assam oil of Turpentine from *Pinus khasya* and Assam Cinchona bark are being conducted on a semicommercial scale and if this proves successful it will be very easy to process cinchona bark here in Assam with local materials as oil of turpentine will be available from the Rosin and Turpentine Factory of the Forest Department in Shillong.

MEDICINAL HERBS AND PLANTS

By

M. L. SAIKIA

The State of Assam with its wide range of climatic zones from the semi-tropical to the almost Alpine possesses a great variety of medicinal plants some of which are commercially important and reputed for their therapeutic effect. From the driest place with 40 inches of rainfall to the notoriously wet Cherrapunjee with 450 inches of annual rainfall, Assam experiences an unique range of rainfall. Variation in elevation and configuration of the ground are also considerable, ranging from elevations of a few feet above mean sea level to snow line heights if the Himalayas are taken into consideration. These variations of rainfall and configuration have largely contributed towards the occurrence of a great variety of medicinal herbs and plants and also present favourable conditions for cultivation of indigenous as well as exotic species of medicinal plants on commercial lines

A number of plants are used both in the indigenous system of medicine as well as in Western systems, as tinctures, extracts, etc., but though the raw materials for quite a lot of drugs are available and some of these are exported outside the State, for lack of proper investigation and exploitation they are mostly neglected.

The Forest Department of Assam is experimenting with some important medicinal plants, both exotic and indigenous, such as *Cephaelis ipecacuanha, Atropa belladonna, Strychnos nux-vomica, Withania somnifera, Ocimum kilimandscharium, Santalum album, Derris elliptica, Milletia pachycarpa Cinnamomum camphora, Hyoscyamus-niger, Digitalis purpurea, Andrographis paniculata, Hemidesmus indicus*, etc., with fair success. A scheme for cultivation of medicinal plants, both indigenous and exotic, according to suitability of locality has been prepared. Three centres based on distinct climatic zones in respect of rainfall and elevation have been contemplated in the Scheme (*a*) Plain area below 1,000 feet (*b*) Intermediate zone (1,000 feet to 3,500 feet) (*c*) Higher zone (3,500 feet to 6,000 feet).

It is understood that the Government of India is financing an experimental Scheme under the Indian Council of Agricultural Research for cultivation of medicinal plants on a zonal basis. In the Eastern zone work has already been allocated to Darjeeling in West Bengal. The Uttar Pradesh Government have started implementing their own Scheme for cultivation of medicinal plants in Chakrata Hills. If the Scheme drawn up by the Assam Forest Department can be implemented on similar lines it will go a long way towards developing the local drug industry by utilising our own resources and thus making our State self-sufficient in the matter of medicinal drug requirements. In a country like India where the Western system of medicine is largely beyond the reach of the vast masses of the rural population, there is obviously much scope for the use of indigenous medicines if they can be made available at comparatively cheaper rates

Some of the more important medicinal plants and herbs are listed below:—

(A) which occur in Assam (B) which do not occur in Assam but are being experimented with and (C) which are likely to succeed in Assam.

"A"

1. *Taractogenos kurzii*—Chaulmoogra—Chaulmoogra oil (Oleum Hydnocarpii) is obtained from the fruit of this tree, which is abundantly available in Assam, Chittagong and Burma. The oil is used in medicines for the cure of leprosy and various other kind of skin diseases. Chaulmoogra seeds are mainly exploited from the Sibsagar and Nowgong Divisions. The residue after pressing out the oil from the seed is a valuable fertiliser,

2. *Mesua ferrea* (Nahor or " Iron-wood " tree).—The seeds of the tree, which are abundantly available in Upper Assam, yield a dark-coloured reddish-brown oil, which may be 70-75 per cent. of the original weight of the kernel. The oil is extracted by cold pressing and is used in medicine and soap manufacture as well as for burning and lubricating purposes. By spliting process, Stearic Acid and Glycerin can be extracted from the oil. Flowers are also used in febrile affections, nausea, palpitation of the heart, leprosy, liver complaints, etc.

3 *Coptis teeta* (Mishmi teeta or Mameera).—The root is a valuable remedy in the debility that follows fever, in chronic dyspepsia and even in mild form of intermittent fever. The active constituent is "Berberine" available in the Mishmi Hills.

4. *Strychnos nux vomica* (Kuchila).—Strychnine is obtained from the fruits of this tree, which occurs in the North Cachar Hills and the Nowgong Division. The preparation from the alkaloid Strychnine is largely used in nervine disorders, bronchitis, Pthisis and chronic constipation, etc. It is also a valuable tonic in acute anaemia. Large quantities of nux vomica seeds are exported every year from India to other continent .

5. *Boerhaavia diffusa* (Punarnava).—The plant has been recognised in the indigenous system of medicines from time immemorial and is indicated in the treatment of dropsy, jaundice. etc. It is specified for all urinary troubles, specially in Uraemia. It occurs in all the plain districts of Assam.

6. *Datura stramonium* (Dhatura).—The seeds are given medicinally in asthmatic complaints. The leaves are applied to boils and ulcers. Active constituent is calculated as "Hyoscyamine".

7. *Gaultheria fragrantissima.*—This is the ' Winter green" of the Khasi Hills. Fresh leaves contain about 80 per cent. Methyl Salicylate, which is valuable for external application in Rheumatism, neuralgia, etc.

8. *Holarrhena antidysenterica* (Kurchi).—The bark and seeds are valuable remedy for dysentery, febrile affections, and loss of tonicity. It is available all throughout the province.

9. *Saraca indica* (Ashok).—The flowers and bark are medicinal. A decoction of the bark is chiefly used with dilute Sulphuric Acid in stopping uterine haemorrhage. Also the extract is a valuable specific for mano-pause, dysmenorrhoea, etc.

10. *Rauwolfia serpentina* (Chandra).—The roots are said to be a reputed cure in snake-bite. The roots and leaves are used medicinally as febrifuge and tonic and as an anthelmintic also in case of dysentery. In the Indian Pharmacopoeial List 1946, the drug is recognized on account of its active content "Rauwolfia", which is a valuable remedy for Blood Pressure, Insanity and Insomnia.

11. *Emblica officinalis* (Amlakhi).—A fermented liquor prepared from the juice is valuable in jaundice, dyspepsia, cough, etc., the fruit contains high percentage of Vitamin "C" (Ascorbic Acid) besides others. Abundantly available in the plain districts.

12. *Vitex peduncularis var Roxburghii* (Ahoi).—Decoction of the leaves is efficacious in black water fever. It occurs in Nowgong, Khasi Hills and Goalpara.

13. *Abroma Augusta Linn* (Olotkambal).—Root bark is efficacious in uterine troubles and is extensively used in Allopathic and Ayurvedic medicines. Available in the plain districts of Assam

14. *Milletia pachycarpa.*—The roots of this species yield an insecticide similar to *Derris elliptica*. The rotenone content so far tested is 3·3 per cent. and is found to thrive well at Umsaw (K. and J. Hills) where a few plants have been collected from the adjoining forests.

"B"

1. *Derris elliptica* (Bakalbih).—The roots of this plant yield the valuable insecticide, calculated as Rotenone. The active content of the root so far tested is 3·58 per cent. The species is being tried at Umsaw (K. and J. Hills) on an experimental basis, by obtaining root cuttings from Malay and Mysore.

2. *Ocimum kilimandseharicum*.—This is said to be one of the best Camphor yielding plants. Seeds were received from the Forest Research Institute, Dehra Dun and the species has been successfully grown in suitable localities of this State. Camphor content of the plant so far tested is 3 74 per cent. which is one of the highest recorded so far.

3. *Cephaelis ipecacuanha* (Ipecac).—A native of Brazil, introduced into India and is being cultivated at the Government Cinchona Plantation, Mungpoo (West Bengal). It is being experimentally tried in Assam with reasonable success. The importance of Ipecacuanha lies in its active content calculated as "Emetine" which is a specific remedy for Amoebiasis. Powdered root is extensively used in British Pharmacopoeial preparations for influenza, dry and hacking cough and other bronchial affections. It is a stomachic and tonic. Extensive cultivation of this plant would pay.

4. *Santalum album* (Sweet Chandan).—The seeds of this tree yield by expression thick and viscid oil, which is burnt by poorer classes of people in lamps. The valuable essential oil is distilled from the wood and is one of the most favoured of the Indian perfumes, and is also used internally as a remedy for Gonorrhoea and other genito-urinary troubles. The paste obtained by rubbing the wood on a piece of stone with a little water is used medicinally for various domestic purposes. The species has been successfully tried at Umsaw (K. and J. Hills) and analytical result of the heartwood show that it contains 4.65 per cent. of oil.

5. *Atropa Belladona*.—The leaves and the dried roots of the plant are medicinal and are used in the advanced stages of whooping cough, spamodic asthma and other complaints. The active constituent "Atropine" is valuab'e in acute conjunctivitis, also in other inflammatory symptoms.

6. *Digitalis purpurea* (Fox glove).—It is valued as a garden plant, but it is a drug of intrinsic medicinal value. The leaves have excellent stimulating properties in nervous debility, in auricular fibrillation and other heart diseases and is extensively used with excellent results. Active contents are calculated as "Digitalin" Digitoxin etc.

7. *Withania somnifera* (Aswagandha).—Root of the plant is tonic and dieuretic. It is also extensively used in nerve fatigue, dropsy, debility, consumption etc.

8. *Cinnamomum camphora*.—This is the main sources of Camphor which is used extensively in medicine.

9. *Elletaria cardamom* (Cardamom, Elachi).—The seeds are agreeably aromatic and these are medicinally used in compound preparations. Cardamons are used in flavouring sweetmeats and certain cooked dishes, also as a spice and are sometimes chewed in pan with betel leaf. It is also used in indigenous medicines for bronchial spasms, cough, uraemia, flatulence etc.

10. *Hyoscyamus niger*.—Hyoscyamus is specially valuable as a nervine sedative and narcotic in cases of maniacal excitement, sleeplessness and nervous depression. Active content is calculated as "Hyoscyamine".

11. *Hemidesmus indicus* (Indian Sarsaparilla).—The root has long been used as an alterative and tonic in syphilitic infections and for purification of blood.

12. *Chrysanthemum cinerariaefolium* (Pyrethrum).—It is known as an ornamental garden plant, but contains a valuable insecticide calculated as "Pyrethrin" which is obtained from the flowers of the plant. It has been cultivated in the Khasi and Jaintia Hills with success.

13. *Saussurea lappa* (Costus root, kuth).—The root is an excellent drug in cardiac asthma also in bronchial spasms, cough, rheumatism, leprosy and eczema.

"C"

1. *Anacyclus pyrethrum DC* (The pellitory of Spain).—The root of this plant has stimulant properties and when locally applied, acts as an irritant and rubefacient. It is given with success in some kinds of headache, apoplexy and chronic opthalmia.

2. *Anthemic nobilis Linn* (Common or true Chamomile).—The dried flower-heads are stimulant, tonic and carminative and useful in constitutional debility, hysteria and dyspepsia.

3. *Aristolochia serpentaria Linn* (The Virginian Snake Root).—The roots of the plant are used to cure the bites of venomous serpents. It is used with good results in diptheria, chronic rheumatism and atonic dyspepsia.

4. *Barosma betulina Bart* (Buchu).—The leaves are aromatic, stimulant, and tonic ; chiefly used in the disorders of genito-urinary organs, also in cases of Gonorrhoea, Gleet etc.

5. *Chenopodium ambrosioides Linn var Athelminticum A. Gray* (The Sweet Pig-weed).—The fruit, leaves, and the whole plant contain anthelmintic properties, also useful in nervous affection, particularly in Chorea. Oil (Violatile) distilled from the whole plant (except the root) is highly valued in expelling round and thread worms.

6. *Piper cubeba Linn* (Kababchini).—The fruit is used as an expectorant and is believed to have the power of increasing the tension of the vocal chords and of clearing the throat of tenacious mucus. It is much used by singers. It is also used in the treatment of all the genito urinary troubles and valuable remedy in Gonorrhoea.

7. *Polygala chenensis Linn.*—The root is given medicinally in fever and dizziness.

8. *Polygala senega Linn* (Senega).—As above.

9. *Rosmarinus officinalis Linn* (Rosemary).—The oil and spirit made from the flowers are medicinal. They are extensively used as ingredients of stimulating liniments for baldness.

10. *Styrax-benzoin Dryand* (Loban).—The tree yields the true Benzoin or Gum Benzoin of commerce, which is used as an internal remedy in Pthisis and Asthma, also as an universal preservative for drugs and foodstuffs.

11. *Swertia chirata Ham* (Chirata).—The drug obtained from the dried plant is a tonic and febrifuge. It is also a valuable blood-refiner and a liver tonic, with anthelmintic properties.

12. *Andrographis paniculata* (Kalmegh).—Very valuable in febrile affection also in cases of jaundice, anasarca and other liver complaints. Active content is "Andrographolide".

13. *Artemisia maritima.*—It is a very valuable drug on account of its anthelmintic properties, specially in expelling the round and thread worms. Active constituent is "Santonin".

PYRETHRUM

By

M. L. SAIKIA

1. General—

Pyrethrum is one of the cheapest and most effective vegetable insecticides and is widely used both in its pure form and in mixture with other insceticides. Pyrethrum (*Chrysanthemum cinerariaefolium*, is grown mainly for flowers which contain an alkaloid called pyrethrin and belongs to the genus *Chrysanthemum* family *Compositae*. Only three species of the genus *Chrysanthemum* are toxic to insects, *Chrysanthemum cinerariaef lium* (Dalamatian species) *Chrysanthemum ros-um* (Persian species) and Chrysanthemum marshalli. The Dalamatian species is the main source of the pyrethrum products of commerce on account of its high Pyrethrin content and its effectiveness as an insecticide.

Three basic products are extracted from the pyrethrum plant (1) flower powder (2) leaf and stalk powder, (3) liquid extract mixtures and from these several derivative products can be obtained. These products are mainly used as antimalarial insecticide and as a means of exterminating bugs, lices, fleas, crop pests, etc.

II. History of Pyrethrum cultivation in India with special reference to Assam—

Japan and Kenya are the two most important sources of pyrethrum products in the world. The importance of pyrethrum cultivation in India was first realised during the last war when the Japanese source of supply was cut off. The increasing demand of pyrethrum for antimalarial works a d for keeping soldiers free from body lices, ticks, etc, while fighting in the jungle has resulted in an all out drive for pyrethrum cultivation in suitable localities of India. Fairly large plantation were started in Kashmir and in the Nilgiris of South India to meet the demand of war time and in Assam also preliminary trials were made by the Agricultural Department with fairly good success and later a company was floated to grow pyrethrum on a commercial scale at Laitlyngkot and Laitkroh in Khasi and Jantia Hills district Kashmir had about 2,760 acres of pyrethrum plantation during the period of 1943 to 1946. Then there was a lapse of about 4 years due to unsettled condition in Kashmir and it was again taken up recently at the instance of the Government of India and a separate Division for the cultivation of pyrethrum and other medicinal plants was created by the Forest Department of the State. A scheme has been taken up to plant about 5,000 acres of land with *Chrysanthemum cinerariaefolium* in the State of Jammu and Kashmir with an estimated yield of approximately 500 tons of pyrethrum annually and the pyrethrum products are expected to be in the market by 1953. The main consumer of the flowers will be however the Drug Research Laboratory at Yarikah, Kashmir.

In Madras about 1,800 acres were brought under pyrethrum cultivation during 1943 to 1944 and total of 2,70,635 lbs. of dried flowers were supplied to the Government of India in the Military Department. After the war the cultivation, however, had to be reduced to 663 acres with an estimated output of 60,000 lbs. of dried flowers, which would be enough to meet the annual requirement of the State of Madras.

In Assam experimental cultivation of pyrethrum with seeds of *Chrysanthemum roseum* (Persian species) was started in 1937 by the Agricultural Department at the Government Fruit Experiment Station, Shillong but the species did not do well. In 1943-44 two varieties of *Chrysanthemum cinerariaefolium* namely Kenya and Harpenden were tried with good success. The dried flowers of these two varieties

were sent to the Imperial Agricultural Chemist, New Delhi for determination of the *pyrethrin* content and the following results were received :—

Chrysanthemum cinerariaefolium	(Harpenden)		1·13 per cent. total pyrethrin.
Ditto ditto	(Kenya)	...	1·04 per cent. ,, ,,
Chrysanthemum roseum	(Ootacamund)	...	·92 ,, ,,

Further trials were made with seeds of *Chrysanthemum cinerariaefolium* obtained from Kashmir in 1941 and the dried flowers were similarly tested. The total pyrethrin content was reported to be 1·408 per cent. which was very encouraging and compares favourably with the Pyrethrin content of other places both in India and outside.

This encouraging results prompted the Government of Assam to approve a 7-year scheme for cultivation of pyrethrum in Upper Shillong Farm and Fruit Station, Shillong, early in 1942 and the scheme commenced from the month of April of the same same year.

Pyrethrum cultivation at Laitlyngkot, Mun and Laitkroh in Khasi and Jaintia Hills by a Company and its results—

In the meantime the Pyrethrum Products Company Limited, a private Indian Farm, started pyrethrum cultivation on a commercial scale in suitable localities of Khasi and Jaintia Hills. Three grants on 7 years lease were given to the company for pyrethrum cultivation and the Government of Assam promised to purchase the flowers when harvested, (*a*) about 30 acres of old village land and 7½ acres of waste land at Laitlyngkot (*b*) about 100 acres of Reserved Forests at Laitkroh (*c*) a thatch covered area of about 100 acres at Mun, a place situated at some distance from Laitlyngkot (but this being an out-of-the way place was not planted out).

A small nursery was first started at Laitlyngkot with seed supplied by the Government of Assam and was quite successful. About 50 acres of land were planted out with the seedlings from this nursery 14" apart on 6 ft. wide terraces with contour drains 1' ft. deep 9' wide. The seedling grew well with very few mortalities and the Pyrethrin content of the flowers was quite high.

In the second year a fairly big nursery of 5 acres was started with seed supplied by Madras Government with a view to planting out the remaining areas, but it was a failure because the Company did not spend money on shading the nursery beds with the result that most of the seedlings died due to heavy rainfall and long exposure to sunshine. Whatever seedling were available were all planted out in the Laitkroh area with good success. The Company also purchased the available seedlings from the Upper Shillong Agricultural Farm and Fruit garden and the splits of these seedlings were planted out both in Laitlyngkot and Laitkroh. The Company eventually failed however and apparently the main reasons for the failure were as follows :—

(1) The time of pyrethrum flowering coincided with the monsoon period which made sundrying of flowers impossible and the company was not prepared to install modern types of artificial arrangements for drying.

(2) Financial difficulties.

(3) Non-co-operation of the local people who were hostile to the Company.

(4) There was a clash of seasons with many of the crops usually grown by the local cultivators.

(5) Last but not the least organisational difficulties of the company whose headquarter was in Calcutta.

III. Locality factors—

(*a*) *Soil.*—Pyrethrum is not very exacting in its soil requirement. It is found to grow in various types of soil, *e.g.*, in Dalmatia, the home of pyrethrum it is grown on rather poor calcareous soils ; in Japan it is grown on barren hill slope which is almost unsuitable for any other crop, and in Kenya it is grown on a better type of acidic soils. In the Nilgiris and Upper Planis of South India pyrethrum is grown generally in two types of soils—namely black loam and red loam which is lateritic in origin and no difference has been noticed in their growth and flower production with the two types of soils. It is reported that in Kenya significantly higher yield has been obtained when the cultivation of some cereal crop such as wheat, rye, barley or oats is followed by pyrethrum cultivation.

(*b*) *Altitude.*—Pyrethrum grows well at elevations varying from 6,000 to 8,000 ft. and the best result has been obtained at elevation above 7,000 ft. in South India (Latitude 8° to 11°N).

It also grows in lower elevation down to 3,000′, but the yield of flowers is much lower when grown at lower elevation. In Kenya it is found that at elevation of 5,500 to 6,000 feet the yield is about 400 lbs. per acre, whereas at higher elevations of 8,500 to 9,000 feet the yield of flowers goes up to 1,000-1,500 lbs. per acre.

The first year's trial at Shillong is reported to have given a yield of 600 lbs. per acre.

In Northern latitudes pyrethrum grows at lower elevations. In Kashmir the best growth of pyrethrum has been reported from elevations varying from 3,800 to 5,000′ feet. The Khasi Hills with an altitude of 4,000′-6,000 feet are eminently suitable for the cultivation of pyrethrum and every endeavour has to be made to establish pyrethrum as an economic crop in the Khasi Hills and other suitable localities of Assam.

(*c*) *Rainfall* —Well distributed rainfall of 40″ to 50″ in a year is generally suitable for pyrethrum. Continuous draught is unfavourable and so is continuous heavy rainfall. Heavy rainfall results in the "damping off" of pyrethrum plants and consequent fall in yield.

IV. Cultivation of pyrethrum—

(*a*) *Nursery technique.*—Nursery beds are to be prepared well in advance of the sowing, preferably on rich and well drained sandy loam, close to a perennial source of water. The soil of the seed beds should be ploughed or hoed deep and reduced to a fine tilth. A little quantity of well-decomposed cowdung also may be applied to the soil. In a reasonably well drained fertile soil no manuring seems necessary. Pyrethrum seeds should be soaked in water for 12 hours and kept wet for a day before sowing. Seeds are then mixed with dry earth or sand and sown broadcast or along drills about a quarter inch deep, the drilled lines being spaced about a foot apart, in standard beds. 4′×40′. They are then covered with a thin layer of earth and pressed gently. The beds are covered with grass laid directly in the soil to protect it from the direct rays of the sun. Daily watering should be done with a fine rose can. Germination generally starts in about 8 day's time and is complete in about 15 days to 20 days. The grass cover should be removed immediately after the completion of germination. Pyrethrum seedlings are very susceptible to "damping off". If any sign of damping off is noticed the grass cover should be immediately removed before the completion of germination and sun rays should be allowed to fall directly on the beds. Three to four ounces of seeds are sown per standard bed and on an average a standard bed 40′×4′ will give 2,800 seedlings. The seed beds should be kept cleanly weeded all the year round. As soon as the seedlings have produced four or five leaves they should be pricked out carefully and planted in vacant beds.

(*b*) *Time of sowing seeds.*—Seeds are generally sown in August and September, and seedlings are allowed to remain in the nursery bed throughout the winter till March or April next when they are to be transplanted in permanent places. In Darjeeling the sowing is done either in April or in September.

(*c*) *Method of propagation.*—Pyrethrum is propagated either from seedlings or from suckers or splits of the parent plant. In Shillong the average number of splits obtained from one year old plant of Kenya variety is reported to be 22 and that of Harpenden variety is 17 only. It cannot be definitely said which of the three methods is better, each having its own advantages and disadvantages. Splits or suckers can establish themselves much quicker specially when the planting is followed by a spell of wet whether and the production of flower is obtained much earlier than that of seedlings. The only advantage of seedlings is that being complete plants with the root system in tact, they can survive better than splits if the planting is followed by a spell of dry weather.

(*d*) *Preparation of ground for planting.*—Pyrethrum is a perennial plant though the pyrethrin content drops on the seventh or eight year when the plantation ceases to be economical. As the plants are expected to be on the ground for a fairly long time it is therefore desirable that all weeds and grass be removed from the planting ground. The soil should be ploughed or thoroughly dug up two or three times before planting to remove all weeds and grasses. Care should be taken not to break the soil to a fine tilth to avoid soil forming a hard mass during the subsequent operation like pricking, weeding, etc.

A well grown pyrethrum plants almost completely covers the ground and it is therefore very effective in preventing soil erosion.

(*e*) *Weeding.*—Intensive weeding is necessary for the first two years. Light hoeing and application of manure such as cowdung, bonemeal in winter is sometimes necessary.

(*f*) *Spacing.*—Sloping ground is to be terraced, or graded trenches are formed along contours at suitable intervals depending upon the steepness of the slope. Grass belts of 5′ to 11′ in width are left alternating with cultivated strips which are 11′ to 30′ in width in the Nilgiris, to prevent soil wash.

The earth in the hoed-up strips is raised to form ridge 6 inches high and two and a half feet a part after being allowed to weather for about 2 months. Pyrethrum seedlings are then planted on the ridge thus formed at a distance of 2 ft. apart along the ridge.

In the Nilgiris the planting is done along a belt of two rows alternating with 2 ft. wide uncultivated belts at an espacement of 1′ × 1′, the plant in the two rows alternating with one another to form a half quincunx.

Planting is usually done in the months of April immediately after the pre-monsoon showers when the ground becomes wet.

V. Harvesting—

Pyrethrum bushes starts flowering in about 8 to 9 months after planting. The flowers are picked by hand ; picking should be done at a time when the pyrethrin content is at its maximum. Such a stage is reached when the last floret in the centre is about to open. Later or early picking is likely to affect adversely the pyrethrin content of the flowers.

The yield.—In Japan the yield of fresh flowers varies from 300 to 1,200 lbs. per acre. In Kenya the average yield is from 1,500 to 1,600 lbs. of fresh flowers and a record yield of 4,000 lbs. have been obtained from certain experimental plantation. In Dalamatia it is from 155 to 800 lbs. of fresh flowers. In the Nilgiris of South India the yield of fresh flowers varies from 127 to 316 lbs. per acre which is a little lower than Japan but in certain fields as high as 1,700 to 1,900 lbs. of fresh flower during the 2nd and 3rd and greater part of fourth year has been reported. In Assam the yield has been recorded as about 600 lbs. per acre which is quite encouraging in the first year's experimental plot and compares

favourably with the average yield of Japan and the Nilgiris. Each wet period of a few days give a good flush of flowers and in a good year during which the rainfall is well distributed it will be possible to take off 4 to 6 major pickings.

After the annual crop is harvested all the stalks of flower should be pruned off.

VI. Drying and packing—

The flowers may be dried either in the sun or in specially constructed artificial driers in which hot air is made to circulate at a temparature of 130° F through ironpipes over which flowers are arranged in specially constructed trays. On non-rainy days flowers can be sundried on cement plastered court-yards or in wiré-mesh trays 6′ × 3′ and 3″ — 4″ deep, raised on specially constructed wooden platforms. The drying is complete when a flower breaks up only when a rolling squeeze is given. Sun drying takes about 4 days.

In a place like Assam where the climatic conditions are such that it is unsafe to rely on-sunshine at the time of harvesting when the monsoon is at its height, artificial drying is the only suitable method. Loss of weight in drying is about 75 per cent.

The dried flowers are packed into gunny bags and stored for disposal.

VII. Pyrethrin content—

The Pyrethrin content of flowers varies from 0·9 to 2·67 per cent. depending upon the climatic condition of different localities. In Kenya the average pyrethrin content is 1·4 per cent. and the highest is 2·1 per cent. and by breeding experiments an improved strain of pyrethrum plant containing 2·67 per cent. pyrethrin has been evolved. In the Nilgiris the pyrethrin content varies from 1·19 per cent. to 2·77 per cent. which is one of the highest in the world. In Japan the average pyrethrin content is 0·9 per cent. and it goes up to 1·2 per cent. In Assam the pyrethrin content varies from ·92 per cent. to 1·13 per cent. and the maximum was reported to be 1·408 per cent., which is quite encouraging.

VIII. Financial aspect—

In the Nilgiris the net profit of pyrethrum cultivation is estimated to be Rs.780 per acre for a full rotation of 6 years, or Rs.130 per acre per annum. The estimates are based on a yield of 100 lbs. of fresh flower per acre in the first year, 1,000 lbs. in the 2nd year, 1,400 lbs. in the 3rd year, and 1,300 lbs. in fourth year.

Conclusion—

Assam is one of the most malarial places in the whole of India and quite a big quantity of antimalarial drugs has to be imported from outside for control of malaria. Pyrethrin being one of the best insecticides, the importance of its cultivation in suitable localities of Assam cannot be over emphasized. Besides, it will be a profitable occupation for the Hill people to grow pyrethrum along with their fields crops, as is being done in the Nilgiris and the very nature of the pyrethrum plants, covering the ground completely on which they are grown, makes it very suitable as anti-erosion plants.

AGAR OIL

BY

B. SAIKIA

Agar or Agaru oil is obtained by the distillation of the fragrant, dark brown, resinous portions of the wood of *Aquilaria Agallocha* or the Sasi tree, which grows mainly in the Garo Hills, Goalpara, Darrang, Nowgong, Cachar and Sibsagar Divisions of Assam. It is also found in the foot hills of Bhutan, in Tipperah, and the Martaban Hills in Burma.

The dark brown patches are not found in all trees and are developed as the result of a certain type of fungus attack. Healthy trees do not contain agarwood, the general indications of its presence being the diseased appearance of the top and side branches. Agar is collected in quantity only when such a tree showing diseased appearance is either completely or partially killed. There are two distinct varieties of agarwood known in commerce. One is the black agar or Krishna Agaru. It is all black and the wood is very hard, the other is Doomagar, the soft pale yellow coloured wood, charged with black spots and is mainly used for distillation of the oil. It is hardly sold as agarwood. The distilled oil of agar is used as an attar and also as a perfume base, while the wood itself is in great demand as an incense material in the whole of the Orient.

The Agar distillation industry in Assam has hitherto been confined in the hands of a particular group of people in the Dakshinbhag area of the Sylhet district, now in Pakistan, and the details of the process of manufacture of the oil had always been a jealously guarded secret with them. The indigenous method of distillation followed for the preparation of the agar oil consists mainly of chipping the agarwood containing irregular patches of dark spots highly charged with oleoresin, into small pieces and then reducing it into a soft pulpy material by husking in a 'dhenki'. The soft pulp like material is then distilled with water from a copper vessel and the dark brown oil of agar, or agar-attar, as it is called, is obtained. Various grades and varieties of agar oil are put on the market at different prices depending on the quality and content of the essential oil.

The scientific manufacture of agar oil from agar wood was recently investigated at the Forest Research Institute, Dehra Dun. As a result of these experiments it has been suggested that a small scale distillation plant consisting of a bettery of four small stills attended by one person at a time with four shifts, working eight hours a day each, could be established by the Forest Department. The process outlined does not differ much from the country method of distillation and consists of soaking the agarwood pieces in water for 60 to 70 hours after which the wood, which becomes comparatively soft, is taken out and superficially air dried, cut into small pieces by hand chopping and further worked into very small pieces by grinding in a mill or a desintegrator or by the country 'dhenki'. The finer the material the quicker and better is the yield. The equipment required for distillation is more or less the same as that required for small-scale distillation variouos essentials oils as followed in different parts of India, and consists of copper or brass vessel or still, with a false bottom on which rest the agar pieces, thereby preventing them from being overheated or charred by coming into direct contact with the bottom of the still which is directly heated by fire. The still has an inlet for introducing water from time to time to make up the losses due to distillation, and the vapour containing steam and essential oil escape through a gooseneck pipe to a worm condenser, from which it drips after condensation into avessel, the oil automatically rising to the surface, where it is skimmed off. The water is drawn off and re-cycled (*i.e.*, put back into the still) until all traces of the oil are removed from the wood. Agar oil has a very high boiling range and therefore the proportion of oil to water in the condenser is very small. Moreover the oil contains its most valuable constituents in the last runs, and this requires the distillation to last for 30-32 hours continuously. Common salt to the extent of 5 per cent. of the weight of the water introduced into the still helps distillation. When the distillation is over the water collected in the condenser is treated with common salt and sulphuric ether to extract the last traces of its dissolved essential oils.

It was bserved that the distillation of agarwood by steam under preasure is unconomical and also steam under pressure deteriorates the aroma of the essential oil.

Agarwood contains about 0·3-0·5 per cent. of oil and the black resin infected portion gives an oil content as high as 3·0 per cent. However the average yield of oil obtained from the so-called 'doom-agar' could be placed at 0·4 per cent.

Agar oil has a very high fixative value in blending perfumes, and as such it is in great demand. Its production cost could be substantially lowered if a regular and sustained supply of agarwood could be ensured. At present the greater proportion of the production cost is taken up in collecting the agarwood from scattered trees in the forests. It is possible that the necessary fungus infection of agarwood can be artificially brought about in planted trees by multiple inoculation with suitable cultures of the fungus and experiments with artificial inoculation of Sasi trees by cultures of agar fungus are in progress and steps are also being taken to grow Sasi trees on a plantation scale. The present hit-and-miss method of the agarwood collectors who fell a uumber of trees to obtain infected wood only from some, is endangering the continued supply of the wood. If artificial inoculation of the development of the agar fungus proves successful, the present position of agar as a chance product will give place to steady industrial production on a large scale in Assam.

OTHER INDUSTRIES

I. Wood Turnery—

Small blocks of waste wood and stumps and branches of trees which are usually wasted can be profitably utilised for the manufacture of articles like bobbins, tool-handles, chair and table legs, spinning-tops, and toys by hand-fashioning and turning on lathes. The Chennapattnam toy-industry of Mysore is probably the best of its kind in India—bamboos and a comparatively valueless species wrightia Tomentosa are turned and carved to produce all manner of toys, whose bright colours and lacquer-finish are their main attraction.

Haldu (*Adina Cordifolia*) is the most suitable wood for Bobbins, which are in great demand, and this species is found plentifully in certain parts of Assam. In addition there are other suitable timbers and this industry awaits development in Assam.

II. Bamboo Work

In Japan bamboo is used to produce all manner of beautiful and useful articles in cottage and small scale industries.

Veneer or Plywood.—from bamboos, called 'Bambania', is a new industry, the bamboos being sliced into thin sheets by a special machine and then processed to produce veneer sheets for furniture, trays, ceilings, pannels etc.

Bamboo mosaic.—is made from blocks built up from thin strips of bamboo arranged cris-cross, glued together and compressed—when the blocks are cross-cut a mosaic effect results. These cross-cut pieces are used for fancy articles as cigarette-cases, ash-trays, buttons, etc. The entire machinery for this industry costs only a few thousand rupees.

Bamboo Bead-Ware.—A thin variety of bamboo is used for this. The bamboo is cut into small pieces with electrically driven saws and these are polished in a rotating wooden drum, dyed various colours, dried and strung together to make handbags, table-mats etc.

Bamboo-Screens.—These are made for export to America. The machinery consists of a power-driven bamboo-peeler and a hand-operated bamboo splitter. The latter is a heavy iron disc-wheel with holes of different sizes, inside which are set 8-10 sharp knives. The bamboo is inserted in the hole and is pushed through it by a weight running on rails and is thereby split into pieces which are then peeled into thin strips and are woven into screens on a treadle-loom.

III. Cane industry

Assam's production of canes is probably the biggest in India, but with the exception of one or two species they do not compare in quality with those from the Malay Peninsula. As a result of the late war exports of Malayan cane dropped considerably and Indian canes got their chance in the foreign markets, but the former have again recovered their place in the world and Indian markets.

The main reason why Assam canes cannot compete in world markets is because no special attention is given to the treatment of the cane once it is cut. Immature canes are often cut and except for natural drying no special efforts are made to artificially, dry or season the canes adequately or to store them hygienically, with the result that they invariably become dis-coloured, brittle and attacked by borers. If the same attention is paid to the preparation of Assam canes as is done in Malaya the quality of the former can be vastly improved. Moreover no attempt at grading of canes is made before marketing them.

In Malaya the canes after being stripped of leaves are rubbed w th sand, washed and air-dried, then sorted and bundled for despatch to Singapore, where they are graded and treated. Those canes with a natural glaze are polished by being rubbed with a twisting motion around a part between two pieces of bamboo, and after being scoured with sand, washed and dried are bleached with sulphur fumes.

Another way of imparting 'colour' to canes is to coat them with coconut or other oil and heat them in a fire.

Cane is an ideal raw-material for cottage industries and though a certain amount of basket and chair-making is done in some parts of Assam, the work is confined to one or two classes of people and is capable of wider application. The main canes exploited in Assam are Jati (*Colamus tenuis*), Tita (calamus spp.) Lejai (*Calamus floribundus*)—the first named is exported to Pakistan in split pieces and is the cane best suited for weaving and other fine work. Tita and Lejai are mainly exported to Calcutta in non-split form for coal and earth baskets, etc.

• A. G. P. (Forest)No.1/52—500—17-7-1953.